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CONTENTS

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HYBRIDIZATION IN PLANT AND ANIMAL IMPROVEMENT

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THE function of hybridization is the rearrangement of already existing characters, the bringing together of qualities scattered about in different forms into one or a few individuals which represent the beginning of a new variety, or a new breed. How the common fruits, flowers and vegetables of our gardens and domestic animals in the fields and about the house have been multiplied into endless kinds by a recombination of a relatively few types becomes apparent when the history of any particular group of plants or animals is reviewed.

The dahlia is one of the most popular garden flowers due largely to its easy culture, simple vegetative propagation and the wealth of colors and forms. The fact that the plants can also be easily grown from seed, giving an astonishing array of markedly different flowers, has made this a fascinating subject for experimentation by the amateur gardener and has greatly increased the number of well recognized varieties. The dahlia was first generally cultivated in Europe in 1789 having been introduced from Mexico. At that time the flowers were single and not greatly different from *Cosmos* and *Coreopsis* which are its nearest relatives. The first double flowered form was recorded in 1814 at which time there were listed some 12 well marked color types. Twelve years later the number of varieties had increased to 60 due to recombinations of the existing color varieties with the double flowered condition and also new shades of color were brought out by crossing and doubtless by mutation as well.

The first Cactus dahlia came to light in 1879. This form was a radical departure from the common type. The margins of the petals were bent back instead of forward giving the flowers a very distinct appearance and a welcome change from the extreme forms which look too artificial. A small flowered and profusely blooming type known as Pompon was also discovered. There now existed four main types based on flower form: Single, Double, Cactus and Pompon. The double dahlias are classified in two groups by the florists as Show and

Fancy according to color pattern. Crossing between the Cactus and Show types produced a new dahlia intermediate in form with the tips of the petals curved backward somewhat like the hooded sweet peas but with the body of the petals broad and bent forward and double as in the Show types. This new creation called the Decorative type is one of the most highly prized and beautiful of all the dahlias. The flowers are not so compact and artificial looking as the Show and Fancy groups, and their fluffiness has much of the beauty of the Chrysanthemum and Aster together with an astonishing array of soft yet brilliant colors. The broad petaled, semi-double peony-flowered dahlia and the collarette type with a row of small and odd shaped petals of different color surrounding the central bud are the latest additions to the ever growing list of varieties of this most popular flower.

The first Cactus dahlia also introduced a new color resembling that of the cactus, *Cereus speciosissimus*, from which fact it originally got its name. Other variations which were brought out from time to time were dwarf plants, plants with long stemmed and short stemmed flowers, flowers with petals divided, others quilled and still others rolled into tight tubes like some China asters. Colors are as profuse in dahlias as in almost any cultivated flower. They occur in self-colored patterns and in variegations which are classified into five different types as shaded, edged, margined, striped and mottled. How the individual variations first arose is, in most cases, wholly unknown but having once been found it is not difficult to see how by recombination all these different flower forms, colors and patterns together with differences in the growth of plants, the more than 3,000 named varieties could be developed in 150 years.

Many horticultural achievements have not been developed by intentional hybridization. Natural crossing between different varieties growing together has undoubtedly been responsible for most of the new forms. Because flowers are so conspicuous new deviations are usually easily detected and so seed saved. Cultivation gives a plant a far greater opportunity for further improvement as compared to wild forms because of the immense numbers grown and the fact that these are more under observation. Careful culture also allows many new forms to live which would be exterminated in the open. Those plants whose valuable part is comprised in conspicuous flowers or definitely marked seeds are more extensively multiplied into different varieties than those plants which are not so easily catalogued. Roses, tulips, irises are a few notable examples of flowers which are widely diversified in form and color. Among the vegetables beans are listed in almost endless variety because the well marked seeds in color and pattern and characteristic pods make the different varieties easily recognized and therefore generally kept true to type.

The way in which many varieties of garden and field crops origi-

THE PROGENY OF A FEW NATURALLY CROSSED BEANS FOUND IN A COMMONLY GROWN VARIETY. THE OUT-CROSSED SEED TYPE AND THE ORIGINAL VARIETAL PATTERN ARE SHOWN ABOVE

nate is well illustrated by a natural cross of a commonly cultivated variety of garden beans. From a plot of Dwarf Horticultural beans the seeds of which are characterized by splashes and stripes of irregular red bands on a light background, a few off-type seeds were found when the crop was shelled. These seeds were densely marked with a thick mottling of dark brown. There were only a few of the seeds among many hundreds of thousands of the Horticultural type but they were very conspicuous on account of their darker color and altered pattern. They were probably due to natural crossing which had taken place the year before as the plants were grown adjoining plants of other varieties. This was proven to be the case when the odd looking seeds were planted and the resulting seeds harvested. Almost every plant was different in color and markings of the seeds. A representative seed from a number of these plants is shown in the figure.

The seeds shown in the illustration having the same markings differ strikingly in color. The differences are abrupt. Although there are eleven distinct kinds of seeds in this lot it can be seen that they are made up of different combinations of color and pattern. In arrangement of color there are three types: self-colored, splashed and mottled. The colors are cream, tan, brown and red. Only a few of the many possible combinations of these characters are expressed in this small number of plants. Each seed is a possible beginning of a new variety. Some of the combinations are undoubtedly hybrid and will break up in

later generations. One of the seeds is an exact reduplication of the parental hybrid seeds. Another goes back to the one known grandparent. What the other grandparental variety was can only be conjectured.

In addition to these striking differences of color and markings the seeds differ somewhat in size and shape. Whether these are genotypical differences or merely modifications due to the growth of the plant can only be told by further testing. The plants which produced these seeds differed in no less degree. They were yellow or green podded and the pods were flat or round. They were diverse in time of blooming and ripening. They were also unequal in productiveness, hardiness, disease resistance, stringiness and toughness of the pods. These are the more important qualities but they are not so surely recognized as the noticeable seed characters.

Natural crossing in this manner has been the most important agency in the multiplication of varieties. Striking variations such as occurred in the beans just described attract the fancy of the gardener. The seeds are saved and sown. The unusual features may or may not persist. Some of them may be an improvement over existing sorts. The seed from the most promising plants is again saved and since beans are largely self fertilized the hybrid combination of characters are quickly reduced in numbers and uniform and constant strains are established in the course of several years, that is, they soon come true to type. The best of these strains are selected and a new variety has been created or rather re-formed. Further testing shows whether the new variety has sufficient merit to be worthy of general cultivation and if it has it soon finds its way into the seed catalogues. Such in brief is an outline of the history of nearly all the commonly cultivated vegetables and flowers.

It is generally thought that selection has brought out these new forms. Such is indeed the case but the variability induced by crossing has made the opportunity for selection to be effective. Those characters which really determine the value of a variety, such as hardiness, productiveness, quality, and which are dependent upon all parts of the plant, are so complex in mode of inheritance that it is not at once apparent that recombination of definitely hereditary factors takes place just as surely as in color and pattern. The changes are usually small in degree and the characters are more easily influenced by the external conditions. For that reason selection is the means of sorting out the best hereditary material and with many plants selection must always be continued to maintain improved varieties at their high level.

The application of selection to plant and animal improvement has not been greatly changed by the recent advances in the knowledge of inheritance. It was used effectively long before Mendel's principles of heredity were known. But in the past much time and effort have been

wasted in selecting variations which were not inherited and which led to no change. Mendelism has shown clearly the distinction between the two kinds of deviations. Only germinal variations can be transmitted permanently. These are brought about either by original changes in the structure of the hereditary units about whose cause almost nothing is known and which are comparatively rare in occurrence, or by the much more usual and frequent recombination arising from crossing. The only sure means of identifying these germinal variations is the progeny performance test.

In one sense hybridization produces nothing new. It merely takes materials which are already in existence and by putting them into different associations makes forms which have never been seen before. This is a common if not universal method of diversification. The Aryan alphabet has only some 30 symbols yet the English language alone has over 450,000 words. All chemical compounds are different groupings of about 80 elements. That hybridization can produce nothing new is equivalent to saying that architects can create no new buildings because they have to use the same bricks and boards, cement and sand they have always used or the musician can write no new songs because he has at his disposal only the same set of notes and modulations. The possibilities for creation by combination are practically unlimited. Particularly is this true in organic substances where each new compound forms a new unit which can associate with other units to form new compounds. The hereditary factors as far as known are compounds so complex that their formulas can not as yet be written.

The history of the more recently created breeds of animals shows that hybridization has furnished the beginnings; controlled matings and careful selection have followed this up. Poultry furnishes many excellent examples of the part played by hybridization in animal breeding. The history of their development is the best known for the general purpose breeds of American origin although all are not agreed as to the foundation stocks. For the Barred Plymouth Rocks, the most popular all around fowl among the farmers of this country, the Dominique furnished the pattern and the Black Java or Black Cochin the size. The Minorca and Brahma were also used it is believed. The first specimens were exhibited in 1869 from Connecticut. The type of body has been fairly well fixed and Plymouth Rocks are now obtainable in several different colors and patterns.

The Wyandotte has a distinct type of its own and is another product of the American breeders. Its short blocky build and compact frame set it off from the other larger and more rangy general purpose fowls but this type is not well fixed probably because more attention has been paid to feathers and color than to body characters. According to some authorities a Sebright Bantam and a Cochin hen were first mated to produce a Cochin Bantam. The offspring were again crossed with

Cochin and also with Silver Spangled Hamburgs. Wyandottes first made their appearance in about 1870.

The Rhode Island Red remained for a long time as a farm fowl and was not considered as a distinct breed and was not taken up by the "Standard" breeders until after it had established its reputation as a utility fowl. It is one of the most variable breeds in color due to its extremely mixed origin. Although the material used is somewhat in doubt both Asiatic and Mediterranean stocks were crossed in native breeds. According to one writer Red Malay, Shanghai, Chittagong, Brahma and Leghorn were crossed in every conceivable way. The red color being distinct from all other common fowls it was easy to establish a new breed. It illustrates well the point that breeds are based on a few outstanding easily seen characters and the more valuable features are built up around them. Such has been the origin of the more recent breeds. With various modifications it is probably typical of the beginning of all breeds of poultry whose past history is now unknown.

Sheep are among the oldest of domesticated animals and nowhere have they been more highly developed than in England. Most of the modern mutton breeds with which we are now familiar had their origin there. Some were so excellently formed since very early times that their beginnings are not known, such as the Southdowns and Dorsets. The former has very fine qualities as indicated by its widespread popularity and from the fact that it has been used in crossing with other local strains to produce many of the now prominent breeds. For example it is generally believed that the Shropshires are the result of crossing Southdowns with the native horned, black faced sheep of Shropshire. Also the Leicester and Cotswold breeds are thought to have contributed something to the prominence of this famous race. Similarly the Oxford sheep grew out of intermixing the Cotswolds and Hampshires, while the Hampshires in turn got their start in crosses of the native Wiltshire and Berkshire sheep followed by judicious use of Southdown rams. Later the Sussex sheep which had a somewhat similar origin were united to make the material out of which have come the modern Hampshires. And to-day in the western states the Department of Agriculture is endeavoring to unite as many of the good qualities of the Lincoln and Rambouillet breeds as possible to form a new one for which the name of Columbia is proposed.

Should one examine the history of the creation of the present day breeds of swine he would find that much the same line of development has taken place. Crossing to bring together desired characters from different types brought out in different places and to serve different purposes, followed by intermating and back-crossing of the progeny and close selection towards a more or less fixed objective—such has been the almost unvarying recent history of the smaller and faster breeding animals. The larger and more slowly reproducing farm animals, the

cow and the horse, are not so easily handled in this way. The creation of new varieties which means the culling out of enormous numbers of inferior individuals is too expensive a procedure to be undertaken without good reason. But is it not a logical assumption from the known history of the smaller animals that crossing has played an equally important part in their early development which had already reached a high plane before the written history of the breeds began?

It has long been stated that the chief contribution of France to agriculture, the Percheron horse, reached its highest development following the infusion of the heredity of the Arabian horse into the native heavy horses after the defeat of the Saracens in 732. Sanders and Dinsmore, recent writers on the Percherons, are, however, strongly of the opinion that the influence of the Arabian horse has been greatly exaggerated and even question whether or not mixing ever occurred in any important amount and persisted. They base their chief argument on the fact that the color pattern of the Percheron is distinct from the markings of the Arabian. Unless this objection is supported by more convincing evidence it can hardly be conclusive as it would not be expected that a complex parental pattern would be recovered completely from such a mixture unless it was specifically selected for. It is a fact that the Arabian war horses were present in France in large numbers and magnificent animals they undoubtedly were. It can hardly be doubted that they were frequently crossed with native stock. How many of their desirable qualities have persisted is largely to be conjectured. But the Percheron differs from the other heavy draft breeds most noticeably in neatness of body and lightness of foot, qualities which could very easily have come from part Arabian ancestry.

Wheat being the most important bread making cereal in Europe and America, naturally a great deal of attention has been given to the upbuilding of this plant. Most of the varieties now widely grown have come from individual plant selections from older varieties. A beardless head in a field of bearded wheat or a blue-stemmed plant in colorless sorts attracts attention. Seed may be saved from such plants and if the progeny prove to be sufficiently distinct and better a new variety is in process of formation.

The Scotch Fife wheat has been popular in the Northern States and Canada. Its origin is typical of many other varieties. David Fife living in Ontario received a quantity of wheat which had come originally from Russia. He planted it in the spring but it proved to be a winter variety and consequently only three heads ripened, these belonging to a single plant. Sown again the following year the wheat proved remarkably resistant to rust and from these few plants the seed was rapidly increased and widely grown. In time a number of somewhat different types of Fife developed and by crossing among these types the Marquis wheat which has played a considerable part in Ca-

THE DIFFERENT TYPES OR AGRICULTURAL SUB-SPECIES OF MAIZE. DENT CORN IS THE STANDARD PRODUCER IN THE MAIN CORN GROWING REGION AND COMBINES FEATURES OF THE NORTHERN GROWN FLINT AND SOUTHERN FLOUR TYPES

nadian wheat growing was produced by William Saunders of the Canadian Experiment Station at Ottawa.

Fultz is one of the best known of the older varieties of American wheats. It originated from three heads of beardless wheat in a field of Lancaster. Later S. M. Schindel of Hagerstown, Maryland, crossed Fultz and Lancaster and out of this came Fulcaster, which is a bearded, semi-hard, red grained wheat considerably resistant to rust and drought. It has been grown generally over the country but particularly in the region from Pennsylvania to Oklahoma.

One of the best illustrations of a successful plant breeding enterprise from the standpoint of practical results obtained was the potato varieties produced by E. S. Carman, late editor of the Rural New Yorker. Rural Blush, Rural New Yorker No. 2, Carman No. 1, Carman No. 3 and Sir Walter Raleigh are varieties which came from a collection of 62 varieties which were gotten together for the purpose of crossing. Artificial pollination proved to be impossible on account of failure to find good pollen but from seed bolls naturally formed (undoubtedly many of the seeds resulted from crossing between different varieties) a large number of seedlings were raised and from these the five best were distributed after careful testing. It is stated that at one time 80 per cent. of the potatoes grown in this country were either Carman's productions or seedlings from them. He accomplished what he set out to do in producing a better potato than the old Early Rose and Peach Blow.

That natural crossing has played a large part in the production of corn varieties of all kinds is apparent to every one. The ease by which pollen is carried by the wind and the practice of growing many different sorts near together or even in the same field maintain a constant state

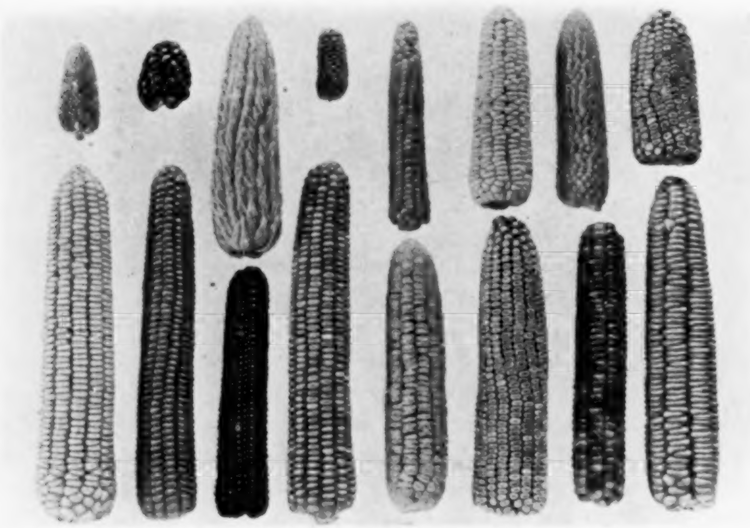
of out-crossing and a resultant variability out of which selection can start new departures.

The history of Reid's Yellow Dent, now one of the most popular varieties throughout the corn belt, is typical. Robert Reid brought with him to Tazewell County, Illinois, from Ohio seed of a local variety know as Gordon Hopkin's corn. This was planted in the spring of 1846 and did not thoroughly mature, consequently the seed did not germinate well the following year. The missing hills were replanted with an early variety known as Little Yellow corn. The corn has not been purposely mixed since then and by selection the type of this well known corn has been developed.

The improvement of the famous variety of corn known as Leaming was first begun in 1826 with the use of Indian varieties commonly grown at that time and is probably the first variety of corn to be systematically selected. It is also probably the first dent variety of modern type to be developed. According to a grandson of the original Leaming[1] some of the material used at the start consisted of the purple or black seeded varieties. Evidences of this aleurone color are still seen

THIS CORN PLANT WITH PERFECT FLOWERS IN A SINGLE TERMINAL INFLORESCENCE IS BOTANICALLY QUITE SIMILAR TO A DISTINCT TRIBE OF GRASSES, THE SORGHUMS, WHICH GIVES CONSIDERABLE PROBABILITY TO THE THEORY OF A HYBRID ORIGIN OF MAIZE

[1] Wallace's Farmer, Dec., 1919.



THE GREAT VARIABILITY OF MAIZE ADAPTING THE PLANT TO A RANGE OF CONDITIONS FROM THE EDGE OF THE ARCTICS TO THE TROPICS THROUGHOUT THE WORLD IS DIFFICULT TO ACCOUNT FOR UNLESS A MIXED ANCESTRY IS ASSUMED

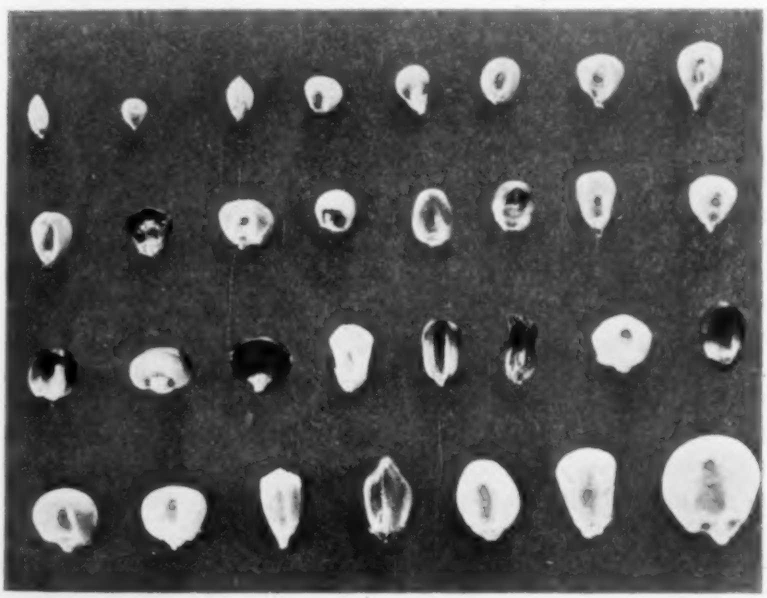
at rare intervals in this variety. That the large-eared, compact-rowed, many-seeded variety now so familiar should be got out of the few-rowed, round-seeded, floury and flinty varieties grown by the Indians for many centuries is a really remarkable instance of plant improvement through hybridization followed by thorough-going selection.

The dent type of corn was not produced for the first time in Leaming as this kind of corn has been known since very early times having been reported to be in the possession of the Powhattan Indians as early as 1608. The characteristic indentation of this most productive kind of corn is due to a corneous outer layer surrounding a center of soft starch. The greater shrinkage of this soft starch than the hard starch outside on drying bring about the depressed and folded tip from which the type gets its name. The two kinds of corn grown by the natives of America were floury varieties in Mexico and adjacent regions and flint varieties in the north. That the combination of flint and floury types has made possible the dent corn now so widely grown is somewhat more than a surmise. The absence of leaves on the modified leaf sheaths forming the husks on the ears, a characteristic of dent corn, is common for floury corn but not flint corn. On the other hand the corneous nature of the endosperm and early maturity are largely flint features.

A familiar example of the rapidity with which varieties can be produced by crossing is furnished by the yellow varieties of sweet corn which have been introduced during the past few years. Practically all of them owe their start to a small eared, yellow seeded va-

riety known as Golden Bantam. This variety for some time was little known and not appreciated because its yellow color differentiated it from all other varieties of sweet corn commonly grown and made it appear like field corn. It was finally realized that Golden Bantam was somewhat more tender in texture and better flavored than any other variety. Its small ears and low yield induced many to cross this corn with the larger growing corns and then to regain the yellow color combined with larger stalks and ears and as much of the quality of Bantam as possible. The yellow color is easily regained because in the second generation following the cross of yellow and white one seed in every four will be pure yellow but retaining the sweetness and tenderness of Golden Bantam in a larger and more productive corn is more difficult. Some success has been achieved judging from the popularity of the new yellow sorts such as Golden-rod, Golden Giant, Buttercup, Bantam Evergreen and a host of others which represent a recombination of the characters of Golden Bantam and such standard varieties as Evergreen, Howling Mob and Country Gentlemen. Yellow color has now become the badge of honor among sweet corns.

The number of new roses continually being offered are so great that only an exceptional variety or novelty creates much interest. Within recent years the climbing American Beauty has attracted considerable attention. This variety was developed from a crossing of American Beauty and Rambler and possesses the large flowered, long



NO OTHER PLANT THAN MAIZE EXHIBITS A GREATER RANGE IN SIZE, SHAPE, TEXTURE AND COLOR OF SEEDS

SIZE OF PLANT IS ALSO ASSOCIATED WITH THE ADAPTIBILITY OF MAIZE TO VARIED CONDITIONS

stemmed features of one parent combined with the profuse bloom and rampant growth of the other.

Practically there are limits to what can be done by hybridization and selection although no one can say exactly what these limits are. Certain characters are antagonistic. Fruit growers dream of an apple with the productiveness and hardiness of a Ben Davis or Baldwin combined with the delicacy, sweetness and flavor of a McIntosh or Northern Spy. Yet the tough skin, thick cell walls and low sugar content of the Ben Davis are probably the very things which make it resistant to disease and able to produce abundantly under adverse climatic conditions.

The plant breeder who sets out to produce a wheat with the best milling and baking qualities together with maximum yielding capacity, resistance to disease and severe climatic conditions has a task which is extremely difficult if not impossible. Likewise the animal breeder can

not expect a rapid maturity and tenderness of flesh together with ability to withstand adverse conditions.

Those qualities which have been developed in domesticated forms are the ones which make them less able to cope with their surroundings. Wild species on the other hand are constantly selected on their ability to endure climatic extremes, pests and diseases. Their chief aim in life is apparently to provide for reproduction. Anything beyond this is a handicap. Moreover there are physiological limits beyond which it is impossible to go. Obviously a cow cannot be expected to give milk which is all cream, neither can a sugar beet be all sugar. What the limit is can not be closely approximated. Certainly if one were familiar with only the wild gourds he would be inclined to think a pumpkin or water melon weighing over 100 pounds a fantastic dream not to be actually realized. The lime tree gives no indication that a near relative could produce a fruit as large as the tropical grape fruit which often weighs over ten pounds. Between the wild cattle in the parks of England and the prize winning Shorthorns and Herefords at the live-stock expositions there are almost incredible changes.

Selection even in the long expanses of time in which plants and animals have been domesticated could not bring these vast differences were it not for the variability made possible by frequent crossings between widely diverse stocks. When the origin of the familiar cultivated plants and domesticated animals is looked into it is significant that nearly all of the more important ones have been derived from more than one wild species and these are usually from separate regions.

As an example of a valuable animal which has been cared for in nearly every part of the world the domestic fowl can be taken. It has long been thought that all the diverse breeds and types of chickens came originally from the Jungle Fowl of India, Southern China and the East Indies but it is now believed that the unknown ancestor of the Aseel or Malay Fowl, which has been bred in captivity for over 3,000 years, is also in part responsible for present divergent development exhibited by the many different breeds and races.

According to Davenport "The Aseel has many points of difference from the Jungle Fowl and brings in a whole set of characters that our domestic races have and the Jungle Fowl lack. Thus the Jungle Fowl is a slender, agile bird with long wings, erect tail and a good flyer; while the Aseel is a very broad, heavy bird with short wings, drooping tail and unable to fly. The Jungle Fowl has a long slender beak, that of the Aseel is short and thick. The comb of the former is single, high, that of the latter triple (or "pea") and low. The former has slender olive colored shanks; the latter thick and yellow shanks. The Jungle Fowl has a red eye; that of the Aseel is pearl colored. The

Jungle Fowl has the well known English Black-breasted Red Game pattern; the Aseel is mottled. The Jungle Fowl is the foundation stock of our nervous, flighty, egg laying races—the Leghorn, Minorca, Spanish, Andalusian, etc.—the races that first spread over Europe, probably from the stock that was brought back from Persia by the expeditions of Alexander the Great. All of these races ordinarily carry the determiners of the Jungle type of coloration. Representatives of the Aseel type (which had long been established in Eastern Indian and China) were brought to America, becoming the ancestors of the Asiatic breeds and the fine general purpose breeds—the Plymouth Rocks, Wyandottes, Orpingtons, etc. Such do not regularly carry the Jungle type of color pattern. In one case on the contrary,—namely the Buff Cochins—they introduced a new kind of color which (arisen in China 1,500 years ago) has never been produced independently since. The fowl of the Aseel type are poor egg layers, but their stocky build and great size make them unrivalled as 'table birds.'"

Of all domesticated animals the dog is probably the most varied in size, in form, in color and in covering. Ranging from the Poodle and Dachshund to the Bulldog, Greyhound and Great Dane, the dog has been the companion of man in nearly every part of the world. The near relatives to the dogs are numerous and although they are truly wild many are capable of being tamed and most of them will cross with some breeds of dogs. The timber wolf of Russia, the Jackal of Europe, Asia and Africa, the coyote of North America and the dingo of Australia have all probably contributed something to present day forms. Even the fox is quite like the dog in certain respects and may be remotely connected with some of our dogs.

Catlike animals are numerous in all parts of the world and more than one species have been brought together in the making of this pet. The common wild-cat of England (*Felis catus*) and the Egyptian cat (*Felis caffra*) are probably the immediately sources of the familiar kinds of cats but the golden cat (*Felis temmineki*) of northern India, Tibet and the Malay Peninsula, the fishing cat (*Felis viverrina*) of India, the spotted leopard cat (*Felis bengalensis*) are near relatives which might have added something to the variety of form and color so characteristic of this animal.

The pig is a widely domesticated animal which reached its greatest development when the breeds of Europe and Asia were brought together and their qualities intermingled. Early in the 17th and 18th centuries Chinese hogs were introduced into Europe and from these sources there grew up the great breeds of Yorkshire, Berkshire, Poland-China and Duroc-Jersey. Many of these breeds have been perfected and named in this country but their foundation stock came originally from England, the Continent, and from Asia. The wild ancestors of the pig are considered to be the wild boar of Europe and Africa (*Sus*

scrofa) and the Indian wild boar (*Sus Cristata*) but almost every region of the earth has its native species more or less closely allied to domesticated swine.

One could extend this recital of the origin of tame animals to show that in the case of sheep there are at least six wild species which could have been drawn upon and a host of more distantly related forms and with cattle domesticated forms are classified in two species, European and East Indian, and any number of closely allied wild species. The horse is rather unique in being the only animal with no closely related wild congeners from which it could be re-established in case the horse became extinct. Either the horse has had a comparatively simple origin or else it has been cared for so long that its prototypes have been lost.

Although much of the history of domesticated races is largely surmised there can be no doubt but that the intercrossing of different species from separated regions has played a very important part in their great alterations to suit the needs of man. Desirable qualities existed in several forms of allied animals in different regions. Tribal migrations and commercial intercourse furnished the means for bringing them together and as far as they were sexually compatible crossing undoubtedly was utilized to combine good features; and also the crossing and resulting variability brought out new possibilities not before realized. How else can one account for the great flexibility of domesticated races as contrasted to wild species?

The same occurrence of species-hybridization is largely at the bottom of the development of cultivated plants. Some forty-two distinct species and sub-species of cotton have been described from both the Eastern and Western Hemispheres.* Many of these are cultivated in various parts of the world. In this country 99 per cent. of the cotton grown is the short staple upland type and the remainder is the long fibered Egyptian or Sea Island cotton, so called as it was grown successfully only on the islands off the South Atlantic coast, and parts of the mainland. It is now grown in Egypt and in the irrigated valleys of the southwest.

Authorities differ as to the origin of the cultivated cottons. Cross-pollination of the plant is easily effected by insects and hybridization between species introduced into new regions has certainly taken place. Watt considers upland cotton to be various hybrids between *Gossypium herbaceum*, *G. mexicanum* and *G. hirsutum*. The former is the old world form which probably originated in north Arabia and Asia Minor. The other two species are natives of the southern United States, the West Indies and Mexico. Sea Island cotton is generally considered as *G. barbadense* originating in Barbados or other West India islands but Watt is convinced that it too has had a mixed beginning. He considers

it as having been developed somewhere in South America and having the Peruvian or Andes cotton, *G. peruvianum* as one parental stock.

Indian corn is perhaps the best example of a widely cultivated plant having apparently a single origin. Belonging to a small subdivision of the grass family its nearest wild relative is teosinte with which it hybridizes readily. Teosinte, *Euchlaena mexicana,* is a large semi-tropical grass which is sparingly cultivated and differs in many ways from maize. The seeds are born in one-rowed spikes. If corn has been derived solely from teosinte there has been a remarkable sequence of changes in that the original condition of two or more spikelets in a place which is typical of most cereals has been replaced by the one-rowed spike in the pistillate inflorescences of teosinte and then regained in the paired-row condition in the ears of maize. Collins has pointed out that there exists in pod corn, *Zea mays* var. *tunicata* a form with perfect flowered terminal inflorescences, which strongly suggests another species as one of the original stocks. These perfect flowered plants can not be distinguished by present botanical standards from a distinct tribe of grasses, the sorghums. In those characters in which maize differs most from teosinte it approaches the characters of this perfect flowered pod corn. Certain other considerations also make it highly probable, although not proved, that maize likewise must be assigned a hybrid origin. The great variability and extreme plasticity by means of which corn is grown in many regions from the edge of the arctics to the tropics throughout the world would be difficult to comprehend on any other assumption.

Of all cultivated plants the rosaceous fruits give the most unmistakable evidence of having been developed by means of species hybridization. Some thirteen wild species of apples exist in the temperate regions of the Northern Hemisphere. Many of these have characters which entered into the make-up of this widely cultivated fruit. The cherry-plum-apricot-peach-almond group intergrades from one to the other so that it is impossible for the taxonomist to fix any exact limits to any division. Bailey lists 75 species and over 150 horticultural types of plums alone. From six native species 300 named varieties have been produced since the settlement of the New World.

The rose itself is both the despair of the systematic botanist and the delight of the gardener bent on originating new forms. The rose grows wilds in nearly all parts of Europe, Asia, Northern Africa and North America. The taxonomists have great difficulty in defining a rose species. Bentham and Hooker list 30 while a French botanist, Gandager, describes 4,266 species from Europe and Western Asia alone. Most botanists recognize over 100 species. The more common horticultural types and the specific names under which they go are as follows:

Horticultural Types and Species of Rose

Ayrshire	*R. arvensis*	Memorial	*R. Wichuraiana*
Banks	*R. Banksiae*	Moss	*R. gallica var. muscosa*
Bengal	*R. chinensis*		
Bourbon	*R. Borbonica*	Musk	*R. moschata*
Champney	*R. Noisettiana*	Noisette	*R. Noisettiana*
Cherokee	*R. laevigata*	Praire	*R. setigera*
Cinamon	*R. cinamonea*	Provence	*R. gallica*
Damask	*R. Damascena*	Scotch	*R. spinossima*
Dog	*R. canina*	Sweetbrier	*R. rubiginosa*
Eglantine	*R. rubiginosa*	Tea	*R. chinensis*

The names of the two principal groups of the large flowered roses, such as the Hybrid Perpetuals and Hybrid Teas, denote their mixed origin. The latter group, of which the variety La France is a popular representative, is the result of back-crossing a hybrid combination of the Provence, Chinese and Cabbage roses on to the tea-scented China rose.

The development of the native varieties of grapes, after the inability of the European varieties to thrive in the Eastern part of this country, furnishes one of the most interesting chapters in horticultural history. Many species of grapes grow wild in North America and individual seedlings of some of these wild forms came very early into cultivation and are still grown. The principal native species and the most important varieties derived chiefly from them are:

Vitis	*labrusca*	Catawba	Concord
"	*rotundifolia*	Scuppernong	
"	*aestivalis*	Norton	
"	*riparia*	Clinton	

From these varieties as basic stock have come nearly all of the many excellent grapes now grown. Concord is the leading variety. In New York 75 per cent. of all the grapes grown are Concords alone. This variety and its derivatives produce three-fourths of the grapes grown in the eastern region. The history of the Concord is obscure but the evidence indicates that it is the product of a large fruited plant of the wild fox grape pollinated by a plant of the Catawba variety which was growing near by. The botanical characters of the Concord are almost wholly *labrusca* but some of the self-fertilized seedlings of Concord show strong indications of influence by *Vitis vinifera*, the European grape. Catawba, one of the assumed parents of Concord, is also a seedling of *labrusca* brought in from the wild but it shows even more indications of *vinifera* characters than Concord in the vinous flavor of the fruit, susceptibility to mildew, appearance of occasional seeds and especially in the seedlings of the Catawba, many of which resemble *vinifera* more than the parent. The Catawba was one of the first native grapes to be cultivated. It originated in 1819 in Montgomery County, Maryland, and is still widely grown. While it is not positively known,

there seems to be little doubt that crossing took place between European varieties and the wild plants growing near by. Large numbers of the *vinifera* grapes were grown at that time in an attempt to find some that would withstand the ravages of unaccustomed insects and diseases in the new world. These chance crosses gave size and sweetness together with resistance and made possible for the first time satisfactory grape culture. Hedrick in the "Grapes of New York" gives the derivation of all the leading varieties. In many cases the parentage is doubtful as many varieties have originated as chance seedlings which were noted as being superior in some respect and propagated for that reason. Out of 205 varieties 74 are the result of a combination of *V. labrusca* and *V. vinifera*. Eighty-eight varieties are more complex hybrids but most of them have either *vinifera* or *labrusca* heredity in addition to other native species. The remaining 43 varieties listed as coming from single species are mainly seedlings of Concord and this, as has been stated, is strongly suspected of a hybrid American-European origin.

The systematic production of new grape varieties is illustrated by the work of Roger, one of the early hybridizers. The American variety Carter was pollinated by Black Hamburg and Chasselas, two European varieties. A large number of seedlings were raised and from this lot 45 were chosen as sufficiently promising to be sent out for trial. From these a number of named varieties were placed on the market and some are still grown of which Agawam is the most popular. The Concord, although the most widely cultivated grape at the present time, is somewhat lacking in quality. It is exceeded in this respect by many varieties such as Diamond, Dutchess and Brighton which have been derived from Concord by bringing in more of the qualities of the sweet European grape.

The opportunities for hybridization of species are not so evident for animals as with plants at the present time. Most of the types and breeds are well established and experimentation with animals is so costly that it is doubtful if radically new forms will ever supplant them. Plants can be raised by the millions for the purpose of producing only a few of merit without prohibitive expense but with animals the situation is different. One instance serves to indicate what the procedure has probably been in the past in the creation of new kinds of animals. The American buffalo crossed by domestic cattle has given a type with the hybrid name Cattalo which is promising as a range animal for the exposed prairies. The first generation progeny of such a cross are sterile in the males but the females crossed back with tame bulls give animals which are still highly variable but combine in various degrees the conformation of the beef breeds with the ruggedness of the buffalo and the flesh also partakes somewhat of that animal which was so highly prized by the native Indian and early plainsman.

This outline of the origin of domesticated animals and plants includes only those forms which show clear evidence of having had a mixed beginning. Not all plants and animals have such a complicated ancestry. The pea and soy bean among plants and horses among animals, as a few examples, have had a comparatively simple line of descent yet they are represented by great variations in nearly every feature and are important additions to the list of cultivated and domesticated plants and animals.

The evidence is sufficient, however, to show that the one word which gives the key to the creation of useful forms of life is *hybridization*. The bringing together of qualities scattered about among different species, their rearrangement and from these still higher developments along strictly new lines this is what hybridization makes possible; and while it is not the primary method of evolution it is the most rapid means of changing animals and plants under the controlling hand of man. When it is noted that the forms which have come into domestication within recent times and especially where rapid progress is made are unmistakably the result of hybridization it can not be doubted that germinal mixing in the past has been a most potent agency in the creation of valuable forms of life.

It is not without significance that the plants and animals in both the eastern and western hemispheres which best serve the needs of man originated at or near the places where the great continents join. Southern Europe, Asia Minor and Northern Africa in the old world have been the birth place of staple cereals such as wheat and barley. Cotton and alfalfa are other plants of great value indigenous in this region. The grape vine, date palm, fig and olive are also native here. Sheep, swine, cattle, and horses were early used in these regions, as far as the evidence shows, for the production of food and clothing and carrying burdens. In the new world maize, beans, long staple cotton, potato, sweet potato, tomato, squashes and tobacco are the outstanding plant contributions and all of them come from Central American or adjoining regions.

In each of the two Hemispheres in which early civilizations developed through long periods of time uninfluenced by each other— the Egyptian, Assyrian in the East and the Inca, Mayan, Aztec in the west— we find the greatest progress in man's achievements made where the paths leading from one continent to another cross each other. During this period of upbuilding use was undoubtedly made of the plants and animals nearest to hand. The fact that diverse forms of life made so by intermingling of different races from widely separated regions were here most abundantly available furnished the best opportunity for the origin of domesticated animals and plants and points the way for future progress.

ADVENTURES IN STUPIDITY: A PARTIAL ANALYSIS OF THE INTELLECTUAL INFERIORITY OF A COLLEGE STUDENT

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A youth whom we will designate as "K" entered Stanford University with credentials showing graduation from a small but accredited California high school. On matriculation he presented 15 units of high school work, all of which were of "recommended" grade. The only suspicious circumstance was the fact that he had spent five years in high school and was almost 20 years old. He registered in mechanical engineering (woodwork), psychology (mental hygiene), drawing (still life, perspective). Three weeks later the instructor in drawing asked me to give the boy a mental examination, because of suspected mental deficiency. This instructor stated that he had never had a student who seemed so completely unable to grasp the principles of perspective or who made such foolish and absurd mistakes in trying to draw simple objects.

A Stanford-Binet test gave K a mental age of 12½ years. Some of the results of this test were so incredible that in the next few weeks I devoted about twenty hours to a further study of the case, applying a large assortment of standardized educational and mental tests. As we shall see later, his scores on the various intelligence scales ranged from 12 to 13½ years, and on the educational tests from the median for grade 5 to the median for grade 9 or 10. Average achievement in the educational tests was not far from grade 7.

K was of course not told the results of the tests. Effort was made, however, to impress him with the fact that he would have to work very hard in order to pass his courses. From time to time I gave him advice on use of references, methods of study, note taking, etc., partly to see whether it would be possible for an individual so lacking in intelligence to pass a college course. K responded with willing, even dogged, industry. He refrained from participation in the usual freshman frivolities and studied every night until 10 or 11 o'clock. It is not surprising, however, that at the end of the term he failed in all his courses and was dismissed from the university. His examination in psychology had included such questions as "Explain how anything is (a) retained, and

(b) brought back to consciousness. Distinguish between (a) philosophy and psychology; (b) sensation and perception; (c) mind and soul"! [1]

In physical and personal appearance K was rather prepossessing than otherwise. He carried himself well and had a pleasant smile and expressive eyes. As he also had good clothes, excellent manners and a high-powered automobile, he was promptly initiated into one of the Greek letter fraternities.

For purposes of observation I invited K to my home for dinner. His behavior and manners gave unmistakable evidence of a home environment above the ordinary. However, in spite of a certain superficial polish, a discerning observer would readily note the extreme commonplaceness of his remarks, and occasional almost infantile crudities of language. He talked little, answering often with only a knowing smile or a softly spoken yes or no. There was something in both smile and voice that tended to disarm suspicion and to incline one to give him the benefit of the doubt, if doubt should arise. His attitude toward me was always one of child-like trustfulness. At no time during the tests did he raise any question regarding the propriety of taking so much of my time, as college students almost invariably do under such circumstances, and at no time did he appear self conscious or apologetic because of his poor showing.

Investigation disclosed the fact that K belonged to one of the most prominent families in the small city where he lived. His father was a banker, proprietor of the leading general store, and had formerly been a member of the local school board. K's mother is said to be a superior woman. K is an only son. His one sister, several years his senior, is a graduate of the University of California.

When K left the university he came to my office to bid me goodbye and told me he was glad it was all over. He said he had not wanted to come to college or even to graduate from high school. He "never could learn books anyway," and now that he had done his best in college and failed he was glad to go back home to work in his father's store.

We will first recount K's test performances in some detail, and later examine them in order to discover, if possible, the psychological nature of their inadequacy.

Stanford-Binet Test

Year VIII, Credit, 12 months.

Although all the tests in this year were passed, K's responses to three of them gave clear evidence of intellectual inferiority. For example, *Finding Similarities* brought the following responses, each given only after 15 to 30 seconds of thinking:

[1] Only one of K's teachers knew anything about the results of the mental tests, or even that such tests had been given.

(a) Wood and coal—"Both used for *firewood*." (b) Apple and peach—"Skin about the only thing." (c) Iron and silver—"Don't know that one. Oh yes, they are heavy." (d) Ship and automobile—"Propeller."

In the *Ball and Field* test K studied for two minutes and said he could not do it. Persuasion finally brought a response which showed barely enough plan to satisfy the requirements for year VIII. Inferiority of practical judgment was evidenced by the crossing of lines and by the lack of parallelism.

Vocabulary. Score 45, or about median for 13½ years. Typical responses: Lecture—"To be taught. Sort of lecture course. One who relates about his experiences." Skill—"Knowledge." Ramble—"Go fast." Civil—"Don't know." Nerve—"Pertaining to mind. Get more nerves. Sort of brain." Regard—"Meaning good." Brunette—"White, I guess." Hysterics—"Pertaining to the nervous system." Mosaic—"Pertaining to architecture from a foreign country." Bewail—"Can't think of that at all." Priceless—"No value." Disproportionate—"Can't think of it at present." Tolerate—"Try to get away from." Frustrate—"Sort of nervous." Harpy—"Happy, I guess." Majesty—"Don't know how to use it. Would it pertain to a queen?" Treasury—"Pertaining to money." Crunch—"Don't know." Sportive—"Pertaining to sport; not sure about it." Shrewd—"Conservative." Repose—"Don't know that one." Peculiarity—"Very peculiar." Conscientious—"Good in his work, I guess." Promontory, Avarice, Gelatinous, Drabble, all met the answer, "I don't know." Philanthropy—"Would it be wealthy?" Irony—"Strong."

YEAR IX. Credit, 10 months. Failed on Rhymes.

No error in *Date, Weights, Change* or *Four Digits* reversed.

Three Words. (a) "The boy *hit* the ball into the river." (b) "Men must work to have money." (c) "The lakes flows into the river and the river comes to a desert where it dries up."

Rhymes. (a) No rhyme found for *day* even in two minutes. "I can't seem to get any." (b) Mill—"Pill, bill, hill, rill." (50 seconds). (c) Spring—"Spring, sprung." Told to give *rhymes*, "I can't seem to think of any."

YEAR X. Credit 10 months. Failed on *Report*.

Absurdities. No error; answers given quickly.

Designs. One correct, the other half correct.

Reading and report. Read passage in 18 seconds without error. "A fire burnt three blocks near the center of the city. There was a girl asleep in bed. While at the fire a fireman burnt his hands."

Comprehension. (a) What ought you to say, etc.—"Nothing." (b) Before undertaking, etc.—"Think about it." (c) Why judge, etc.—"Actions count more. You can see him so much on his actions. Actions usually tell a great deal about a man. He might not have much talking ability."

Sixty words. In successive half minutes gave 19, 15, 10, 11, 7, and 7 words; total 69. Hardly any of the words given were what Binet would call "aristocratic" words. Class series all very brief.

YEAR XII. Credit, 21 months. Failed on *Ball and Field*.

Abstract words. Hazily explained but all scored plus.

Dissected sentences. (a) and (c) correct. (b) "I asked my teacher for paper to correct."

Fables. (a) Hercules and Wagoner—"Don't sit in the same rut and call for help but get out and do it yourself." (Half credit.) (b) Milkmaid—"Not

to be thinking so far ahead." (Full credit.) (c) Fox and Crow—"Let's see. I know, but can't think. The crow was too vain of herself." (Half credit if liberally scored.) (d) Farmer and Stork—"That the innocent sometimes may be caught and the guilty get away. You must not judge all by the ones being caught." (No credit.) (e) Miller, son and donkey—"Mustn't do everything what other people tell us." (Full credit.)

Five digits reversed. One of three correct.

Picture interpretation. First picture brought description only, the others were fairly plausibly interpreted.

Similarities. (a) Snake, cow, sparrow—"Don't know unless it would be the tail." (b) Book, teacher, newspaper—"Learn knowledge from all of them." (c) Wool, cotton, leather—"Clothing." (d) Knife-blade, penny, piece of wire—"Steel." (e) Rose, potato, tree—"Skin, or the heart." (The first three were scored plus, the last two minus.)

Year XIV. Credit, 12 months. Failed on *Vocabulary, President and king, and Clock problems.*

Induction. Answers were 2, 2, 4, 8, 12, 32. That is, the principle was grasped only at the last folding.

President and King. (1) "President has more power. He has a cabinet and rules over the cabinet. A king is mostly a figurehead and is ruled over by parliament." (2) "President is commander-in-chief of the army." (3) "President has the veto power and a king has not." (Scored plus on power, minus on accession and tenure.)

Problems of Fact. (a) and (b) both plus. (c) Indian coming to town—"Carriage; wagon."

Arithmetical Reasoning. All correct in 20, 30 and 7 seconds, respectively.

Clock Problems. (a) 6:22—"It would still be 22 after 6." (Task explained again.) "Will it go like this—25 after 6?" (Failure in 2 minutes.) (b) 8:10—After 2 minutes, "I can't do it." (c) 2:46—After 1½ minutes, "I see now, it would be 15 after 10."

Average Adult. No credit.

Responses on Vocabulary and Fables have already been described.

Abstract Words. (a) Laziness and idleness—"One is not willing to work, and other because he won't work." (Scored plus, but is hazy.) (b) Evolution and revolution—"Revolution means revolves. Don't know the other word." (c) Poverty and misery—"Poverty is without means, misery might be with means but not wanting to use them. One suffering." (Plus on liberal scoring.) (d) Character and reputation—"Reputation is what you *have* had, character is what you have got at present."

Six Digits Reversed. No success. Not over two successive digits given correctly in any series.

Enclosed Boxes. (a) and (b) correct. (c) "10." (d) "17."

Code. Time, 5 minutes and 40 seconds. Only two letters correct.

Superior Adult. No credit.

Paper cutting test. Made one hole in center of paper.

Eight Digits Forward. Not over three successive digits given correctly in any series.

Thought of Passages. (a) "Tests that you are giving at present is very good for the scientific—let's see—the scientific way. This test may help a person in something what they take up. I forget the rest." (b) "Let's see—many people—happiness—we do not have all happiness in life—and many people wish upon us that—let's see—I can't get it."

Seven Digits Reversed. Would not attempt.

Ingenuity test. Showed no comprehension of the task whatever, although I twice explained it and even solved the first problem for him.

The mental age score is 12 years, 5 months. The distribution of successes and failures does not differ especially from what one might expect of an average child of 12 or 13 years. Qualitatively, however, many of the responses are characteristically different from those of an average child of the same mental age. They show more of what Binet called "maturity" of intelligence, and less of "rectitude."

K's 14 years of schooling have brought his vocabulary about a half year or year above the average of his mental age and have made him a fairly fluent reader (pronouncer of words). He makes change quickly and solves simple arithmetical problems, but in practical judgment, in finding likenesses and differences, and in a certain inaccuracy and slowness of thought suggesting faint awareness, his stupidity is more apparent.

Yerkes-Bridges Point Scale

Total score, 79 points, or about median for 13 years.

The following failures were typical:

Repeating 21 syllables. Three errors.

Absurdities. (a) I have three brothers, etc.—"Let's see. It should be Paul, Ernest and *I*." (b) Swinging cane with hands in pocket, etc.—"That one's all right." (c) Guidepost directions (if you can't read this sign inquire of the blacksmith, etc.)—"He never would be able to find the blacksmith.

Analogies. (b) Arm is to elbow as leg is to—"abdomen." (c) Head is to hat as hand is to—"arm." (d) Truth is to falsehood as straight line is to—"I have to pass that one." (e) Storm is to calm as war is to—"Have to pass that too." (f) Known is to unknown as present is to—"Known. No, I don't know."

Yerkes-Rossy Adolescent Point Scale

Total score, 48 points. Satisfactory age standards are not available for this scale, but 48 points is probably not far from average for 13 years. Typical responses include the following:

Digits Forward. Memory span, 5 digits.

Repeating Sentences. Failed on all sentences of more than 14 syllables.

Comprehension Questions. (b) Actions versus words—"What they usually do is what they usually say." Asked to explain, "What a person usually does, he has his mind made up and if he should say anything that way his mind would run in the same order." (c) Why honesty is the best policy—"Because you're never caught in a lie; if you are, always there's nothing to hinder you from getting a position."

Definitions. (d) Conceit—"One who only thinks about himself. One who thinks nobody is as good as he is—the branches of work what he's in—pretty, or anything that way."

Analogies. Whole is to part as six is to—"half." (f) Sunday is to Saturday as January is to—"February."

Opposites. Wise—"not wise." (20 sec.) Silent—"still" (18 sec.). Similar—"things" (20 sec.). Cheap—"goods" (7 sec.). Never—"will" (12 sec.). (Here task was explained again, as it was evident K had lost the goal) Joy—"gloom" (4 sec.). Prompt—"late" (6 sec.). Vacant—"don't know." Busy—"dull" (12 sec.). Distant—"close" (3 sec.). Lazy—"don't know" (35 sec.). Easy—"hard" (2 sec.). Generous—"close" (3 sec.). Horrid—"mild" (12 sec.). Rude—"good" (5 sec.). Top—"tail" (13 sec.). Many—"few" (2 sec.). Rough—"calm" (4 sec.). Upper—"lower" (3 sec.). After—"before" (2 sec.).

Letter Line Test. Only one point credit.

Code Learning. No credit.

Army (1917) Individual Examination

Of tests A to V of the original individual examination methods prepared for use in the army (1917), the following were given:

Clock Test. Could tell time promptly and, when clock was visible, could tell what time it would be if hands were reversed. Failed on latter when clock was not visible. (About a 12 or 13-year performance.)

Knox imitation. Six successes in ten trials. No success beyond five moves.

Porteus maze. One error in 10-year maze, two in 11-year maze and none in mazes for 12 or 13 years. (About a 13 year performance.)

Orientational information. No failure.

Vocabulary. Average for two series of 50 words each was 21 correct definitions. Easy words failed included voluntary, perpetual ("motion in a line"), embers, tragic, optimist, repent, capitulate, contemplate, bestow, cooper ("builds coops"), hypocrite ("sort of non-believer"), etc. (About a 13½ year performance.)

Disarranged sentences. Two of three correct. (12 years).

Absurdities. Series 1 and 2, twenty absurdities in all, were given. Only the following were failed: Series 1 (i)—A mistake is much worse than a lie, for all people make mistakes and all liars tell lies; Series 2 (g)—Just before sunset we sat in the shade of a tall tree and amused ourselves by watching the shadows as they gradually grew shorter and shorter. (At least a 12 year performance).

Rhymes. For *stone* three rhymes were found in one minute, for *permit* one, and for *resist* four.

Likenesses and Differences. Series 1 and 2 were given, on 20 items in all. There were six failures, besides several passes of low value. (12 or 13-year performance.) Typical inferior responses were as follows:

How hat and coat are alike—"Both gold rimmed."
Rose, potato, and tree—"Can't get that."
Animal and plant—"Both have hearts."
Lamb, calf, and child—"All have feet."
Grass, cotton, tree, and thistle—"All green."

Memory for Designs. Of the five designs, two were reproduced correctly and two half correctly (liberal scoring). This is probably about a ten-year performance.

Logical memory. Passages 1 and 2 were given. These are perhaps slightly more difficult than the Binet passage (Fire in New York), and have 20 "memories" each. Both were read fluently and without error. Seven memories were given for the first and 11 for the second. (11 or 12-year performance).

Comprehension. All five series were given, or 25 in all. There were eight failures. (About a 10 or 11-year performance). The following errors are typical:

Why are people who are born deaf usually dumb also?—"Don't know."

You are hauling a load of lumber; the horses get stuck in the mud, and there is no help to be had. What would you do?—"Go for help."

Why has New York become the largest city in America?—"Because of its size and wealth. It covers such a large area."

Why should women and children be rescued first in a shipwreck?—"There ain't any reason."

Why should people have to get a license to get married?—"There would be too many marriages."

Sentence Construction (3 words). All five series given, 15 items. All the responses were correct. (This test belongs at 9 or 10 years).

The scoring of this series of individual tests has not been standardized and age norms are lacking, but I estimate that the value of K's performance is about equal to that of an average child of 12 or 13 years.

Miscellaneous Tests

Trabue Completion Tests. Series B. (3) "The stars and the *stripes* will shine tonight." (6) "She *could* if she will." (7) "Brothers and sisters *should* always *try* to help *the* other and should *not* quarrel. (9) "It is very annoying to *have a* tooth-ache, *which* often comes at the most *bad* time imaginable." (10) "To *make* friends is always———the———it takes." (Score is 12, or approximately seventh grade ability).

Series C. (6) "The boy who *studied* hard *will* do well." (7) "Men are more *capable* to do heavy work *than* women." (8) "The sun is so *hot* that one can not *sit in it* directly *without* causing great discomfort to the eyes." (9) "The knowledge of *man to* use fire is———of———important things known by——but unknown——animals." (10) "One ought to *take* great care to *do* the right———of———, for one who———bad habits———it———to get away from them." (Score again is 12, seventh grade ability).

Easy opposites. The easy opposites of List 3, Whipple's Manual, brought the following responses: (1) Best—"poor" (3.2 sec.); (2) weary—"tired" (2.4 sec.); (3) cloudy—"clear" (.6 sec.); (4) patient—"impatient" (2 sec.); (5) careful—"not careful" (5 sec.); (6) stale—"old" (.8 sec.); (7) tender—"tough" (1 sec.); (8) ignorant—"bright" (.6 sec.); (9) doubtful—"don't know" (6 sec.); (10) serious—"number" (3 sec.); (11) reckless—"not reckless" (.8 sec.); (12) join—"not joined" (1.2 sec.); (13) advance—"not advanced" (3.6 sec.); (14) honest—"dishonest" (.6 sec.); (15) gay—"don't know" (9 sec.); (16) forget—"remember" (.8 sec.); (17) calm—"rough" (.8 sec.); (18) rare—"tender" (.6 sec.); (19) dim—"bright" (.8 sec.); (20) difficult—"easy" (.6 sec.).

By the usual method of scoring only 8 of the 20 responses are correct. Although reliable age norms for this list are not available, this is probably no better than children of 9 or 10 years ordinarily do. The haziness of K's mental processes and his difficulty in holding to a goal are especially striking. The average time is 3.3 seconds, as compared with the Woodworth-Wells norm of 1.11 seconds for adults. This large difference is in line with K's time record in the Kent-Rosanoff test and suggests marked intellectual inhibition.

Whipple's information test. After checking up the words as marked, it was found that K was able to define only 5 of the 100 words and to give a rough, inexact explanation of only 5 others. This is probably not far from an average eighth grade ability.

Matching proverbs test (Otis). K was given the three Otis provisional lists. These resembled the form of the test included in later published editions of the Otis Group Scale, but were not identical with the latter. K's scores on the three lists were 4, 9 and 6. The average of 6.3 represents about eighth grade ability.

Absurd pictures. The Terman series of 44 absurd pictures was next given.[2] As these do not measure above 12 years, it is not surprising that K succeeded with all but two. His intellectual deficiency is clearly not found chiefly on the perceptual level.

Group Examination A (Original 10-Test Alpha)

Test 1. Oral Directions. Only 2 correct. Weighted score 6. (About 8½ years).

Test 2. Memory for digits. Four correct. Weighted score, 8. (About 9 years). Extreme memory span, 5 digits. (8 or 9 years).

Test 3. Disarranged sentences. Nine correct, 3 wrong. Raw score, 6; weighted score, 12. (About 12 years.) People are many candy of fond—marked false. Property floods life and destroy—marked false.

Test 4. Arithmetical reasoning. Raw score, 6; weighted score, 18. (12½ years.) How many hours will it take a truck to go 66 miles at the rate of 6 miles an hour?—Ans. "10." If you buy 2 packages of tobacco at 7 cents each and a pipe for 65 cents, how much change should you get from a two-dollar bill?—Ans. "1.28."

Test 5. Information. Raw score, 28; weighted score, 56. (About 16 years.)

Test 6. Synonym—Antonym. Score, 21. (About 16 years.) Score of this test is not weighted. Omitted definite—vague, concave—convex, adapt—conform, debase—exalt, repress—restrain.

Test 7. Best Answer. Five attempted, 4 correct. Weighted score, 12. (About 11½ years.) Why judge a man by what he does rather than by what he says?—"It is wrong to judge anybody."

Test 8. Number Series Completion. Raw score, 7; weighted score, 14. (About 15 years.)

Test 9. Analogies. Six correct. (About 10½ years.) This test is not weighted. Omitted or failed on items like the following:

(5) Dress—woman: feathers—(bird, neck, feet, bill);
(6) Water—drink: bread—(cake, eat, coffee, pie);
(7) Shoe—foot: hat—(coat, nose, head, collar).

Test 10. Number Cancellation. Score, 19. (About 15 years.)

Total weighted score, 175. This is about median for the high seventh grade, or age 13½ to 14, and is approximately equivalent to score 70 on Alpha. The lowest score earned by any Stanford University student in a group of 300 tested was 205. However, K evidently does consider-

[2] Described in *J. of Applied Psychology*, 1918, vol. 2, p. 348. The pictures themselves have not been published.

ably better on this kind of test than on tests of the Binet type, perhaps because it is more subject to the influence of schooling.

Kent-Rosanoff Association Test

K presented no symptoms whatever of psychopathological tendencies, but the Kent-Rosanoff test was given in order to compare his responses with those found by the authors for typical dull subjects. The results showed 14 per cent. of "individual" and 4 per cent. of "doubtful" reactions. Kent and Rosanoff found 6.8 per cent. of individual responses for normal adults, 14.3 per cent. for normal ten-year olds, and 26.8 per cent. for insane adults. Eastman and Rosanoff found 13.2 per cent. for delinquents (presumably averaging much below normal in intelligence). Accordingly, as far as individual responses are concerned, K's performance resembles that of a dull youth or normal child.

The median frequency of the responses was 22, which is considerably lower than for normal adults. In this case, the low score indicates dullness rather than mental eccentricity. There were no predicate reactions.

There was only one instance of failure to respond, and seven instances of perseverance. These figures are not greatly different from those found for normal adults.

Average reaction time was 3.1 seconds, ± 1.54. The average for college students is usually between 1.5 and 2.25; for children or mentally inferior adults, about 3. Four responses required more than 10 seconds. K's slow reaction time, as well as the quality of his responses, indicates mental inferiority.

Educational Tests

Handwriting. Smooth and legible, entirely lacking in infantile qualities. Grades 14 on Thorndike scale.

Kansas silent reading. Slightly better than eighth grade ability.

Buckingham spelling test. Lists 1 and 2. Better than ninth grade ability.

Courtis arithmetic. The results are shown in the following table:

Process	Attempts	Right	Notes
Addition	16	11	Far above eighth grade.
Subtraction	14	11	About eighth grade.
Multiplication	11	7	Slightly below eighth grade.
Division	7	4	Between fifth and sixth grade.
Speed of Reasoning	5	2	About fifth grade.

The striking thing in the above table is the rapid deterioration in quality of performance in the successive parts of the test from addition to reasoning. That is, the higher the mental processes involved in a test, the more clearly it brings out K's subnormality. In speed and accuracy of adding he compares favorably with the average high school pupil, while in arithmetical reasoning he is little above fifth-grade ability. Three errors, all as absurd as the following, were made in indicating operations necessary to solve problems:

1. The children of a school gave a sleigh-ride party. There were 9 sleighs used, and each sleigh held 30 children. How many children were there in the party? Ans.—"Subtract."

History. History was K's favorite school subject. He had studied it for four years in high school, covering ancient, medieval and modern, English, and American History. Van Wagenen's American History Scale (Information B) was first given. From K's responses, we learn that New York was settled by the English, that the Missisippi Valley was first explored by the United States and England, that Lafayette and Hancock were American generals in the Revolutionary War, that Jamestown was not settled until after the fall of Quebec and the capture of New Amsterdam by the English, that Louisiana was not purchased until after the Missouri Compromise and the Dred Scott Decision, and that Alexander Hamilton was president of the United States. This list of interesting facts could have been greatly extended. The performance indicated about seventh or eighth grade ability.

Sackett's Ancient History test was also given. This is also chiefly an information test. The test is in six parts.

I. What the following were noted for: Hannibal, Cheops, Solon, Attila, Mithridates—"Don't know"; Demosthenes—"Great writer"; Charlemagne—"He was a ruler over Egypt"; Constantine—"Ruled over Egypt."

II. Name one of each of the following, from ancient history: a sculptor, a historian, a philosopher, a builder, a poet—"Don't know." A painter—"Raphael"; law-giver—"Demosthenes."

III. Historical significance of important events. K could tell nothing whatever about the historical significance of the Battle of Tours, the Age of Augustus, the Check of the Saracens, the Reign of Alexander the Great, the Age of Pericles, the Burning of Carthage, the Peloponnesian War, etc.

IV. Important battles. Could not tell who fought or won any of the important battles listed.

V. Important dates. The closest he came to any of the ten dates was about 100 years. The Roman Empire was established about 100 A. D. and fell to the Barbarians about 261 A. D. The Saracens were also defeated around 100 A. D. Most of the events in this list he had "never heard of."

VI. The most important contribution of each of the following to civilization: Greeks—"No idea unless ships. Sort of a fleet is what they had mostly." Teutons—"Came from Northern Europe. Don't know what they gave to the people." Phoenicians—"Don't know who they were." Saracens and Arabians—"Don't know." Romans—"Don't know, unless it was the great art what they had." Hebrews—"Hebrew language only thing I know." (Who were the Hebrews?) "Don't know who they were." (Are they related to the Jews?) "Sort of same thing; are not Jews, though." Persians—"Don't know." Egyptians—"Don't know." Babylonians—"Don't know." Prehistoric Man—"Don't know.'

K's stock of historical information may be inferred from the fact that of the 55 questions in the above six series, 2 were answered correctly. He did know that Cicero was an orator and that Alexander was a warrior ("general").

Notes on Reading and Hobbies

Reading. K stated that from the time he entered high school he had read from one to two hours a day, chiefly newspapers and magazines. The latter included *American Boy, The Youth's Companion, Popular Mechanics, The Literary Digest* and *World's Work.* Asked what books he had read through, he could name only the following: *Little Women*, Alger's books, *Robinson Crusoe,* and several volumes of Draper's *Self Culture.* Said he had also read a book about the Civil War, but could not name it. Could not remember that he had ever read a book of travel, any novel, or any books on mythology. He had read no poems except those in his school texts—"I don't like poetry."

Hobbies. Seems never to have had any persisting hobbies. Four years earlier had put up a telegraph line, which worked, and learned some of the Morse code. This interest lasted only one winter. Had never tried wireless telegraphy. Once he "helped" another boy construct a biplane model. It seems that this was a simple affair and that K played only a minor rôle in it. Can ride a motorcycle, but "does not take care of it himself or try to fix it when it is out of order." Likes an auto better; says he can grease it, fix the fan belt, repair punctures or adjust the carburetor. However, could not explain the principle of the gas engine or tell what the carburetor and commutator are for. Has never had a set of tools and admits that he was "never much good" with them.

The Psychology of Stupidity

The details of K's test performances have not been set forth merely as amusing illustrations of intellectual gaucherie. Let us see what light they throw on the psychology of stupidity, for the essential nature of intelligence or stupidity is best grasped by thoughtful observation of the bright or dull mind in action.

First, however, it will be well to note that the degree of stupidity with which we are here concerned is really not extreme. K is in fact only moderately less dull than the average of the genus homo, judging from the intelligence scores made by nearly two million soldiers. His intelligence is probably not equalled or exceeded by more than 70 per cent. of our white voters, by more than 50 to 60 per cent. of semi-skilled laborers, by more than 40 to 50 per cent. of barbers or teamsters, or by more than 20 to 30 per cent. of unskilled laborers. It is probably not equaled or exceeded by more than 30 to 40 per cent. of our South Italian or by more than 20 to 30 per cent. of our Mexican immigrants. Compared to the average American Negro, K is intellectually gifted, being equalled by probably not more than 10 to 15 per cent. of that race. Among the Jukes, Kallikaks, Pineys or Hill Folk, he would represent the aristocracy of intellect. Just as we are prone to forget how the other half lives, so we are equally likely to forget how the other

half thinks. It is now fairly well established that the strictly median individual of our population meets with little success in dealing with abstractions more difficult than those represented in a typical course of study for eighth grade pupils, that the large majority of high-school graduates are drawn from the best 25 per cent. of the population, and that the typical university graduate ranks in intellectual endowment well within the top 10 per cent. K is stupid only by contrast. Only occasionally does an individual of his moderate ability manage to graduate from high school or enter college. Only an exceptional combination of dogged persistence and parental encouragement or other favoring circumstances can accomplish it. But the introduction of intelligence tests is showing that the majority of colleges and universities do unknowingly enroll a few students of K's intellectual caliber. How this happens and how it may be prevented are questions with which we are not here concerned.

In what, psychologically, does K's stupidity consist? Certainly not in the ordinary sensorial, perceptual or sensorimotor processes. In visual acuity he probably equals or exceeds the average savant. In the cancellation of given letters or figures in a mass of printed matter he would rank little if at all below the average of college students. He is probably in less danger of being run over by an automobile than the average college professor. He can probably drive an automobile as skillfully as the average lawyer, doctor or minister could do with the same amount of experience. There is nothing in his intelligence that would prevent him from reaping world renown as a champion athlete. His handwriting would be a credit to a statesman. His spelling is unquestionably more accurate than the spelling we find in the letters and official reports of Colonel Washington, afterward the savior and the father of his country.

Going from these relatively simple functions to the slightly higher processes of memory, we at once find unmistakable evidence of K's mental inferiority. His memory span is only five digits, direct order, and four digits, reversed order. But we have to do not merely or chiefly with a weakness of memory for discrete impressions. He is able to recognize and pronounce almost any printed word in his spoken vocabulary, but his memory span for words making sentences resembles that of a child of eight or ten years. His "report" of glibly read passages of the newspaper type is childish in its scantiness and inaccuracy, while his report of abstract passages rises little above zero efficiency. He is sometimes able to carry out directions given orally in 15-word sentences, but he responds with only a blank stare to similar directions in 30 to 40 word sentences. So many sounds will not coalesce in his mind into a meaningful whole. Nor is this weakness confined to memory for words, for he does little better with simple geometrical designs. He

is unable to reproduce correctly simple geometrical designs because he apperceives the figures merely as composed of many lines in apparently complex relationship to one another.

How can we reconcile this apparent weakness of memory with the fact that K's fund of general information, as measured by the army test, is equal to that of the average high-school sophomore? Does not the acquisition of information depend upon memory? The answer is that it depends largely on the kind of information. The kind called for in the original form of the army test relates largely to every-day perceptual experiences (common animals, plants, advertisements, sports, etc.). In information involving memory for abstract terms or appreciation of logical relationships, K makes a ludicrous showing. Information about base-ball champions or movie stars is within his reach; historical information is not.

K's success is no more brilliant when it comes to feats of constructive imagination. He was able to draw a clock face so as to show the position of the hands at any specified time, but he could not in imagination reverse the hands. He could not construct in imagination the situation represented by the problem of enclosed boxes. In the Binet paper cutting test, he could not imagine how the notched sheet of paper would look when unfolded. He could not retain or manipulate visual imagery well enough to reproduce the letter code. To think out new combinations of machinery or forces, as in the field of mechanical inventions, appears to be as far beyond him as the ability to manipulate abstract language symbols.

The weakness of K's constructive imagination is also shown in his lack of resourcefulness in meeting practical difficulties like those involved in the Ball and Field problem, the ingenuity test or the Knox Imitation test. The latter is not, strictly speaking, an imitation test, for success in its more difficult parts depends chiefly on adopting the scheme of numbering the positions, as 1, 2, 3, 4, etc., and remembering the numbers. This required resourcefulness is of a kind K can not bring to bear on a new problem. If he were a factory laborer, he could doubtless be taught to perform satisfactorily fairly complicated kinds of routine work, but he would not be likely to devise any new procedure to make work easier or lighter.

In the appreciation of absurdities of a kind which are chiefly on the perceptual level or which involve only the simplest of ideas (absurd pictures), K makes a fairly good showing. He shows somewhat less ability to detect absurdities expressed in language, particularly if expressed in fairly long or complicated sentences. To absurdities on the level of the abstract he is of course blind. He would doubtless read without the slightest suspicion of fraud a poem or sermon or legal document constructed so as to contain nothing but absurdity, provided

only the language was sufficiently smooth-flowing. The absurdity about the road which was down hill in both directions involves little more than the re-presentation of sensed experience, hence was well within K's ability. That about the three brothers demands an appreciation of language relationships which proved to be beyond him.

In "Combinative ability" of the kind which Ebbinghaus rightly regarded as such an important aspect of intelligence, K reveals, notwithstanding fourteen years of schooling, the capacities of an average child of twelve years. His desert-rivers-lakes sentence is correct in form, but absurdly foolish. In the Trabue test we find habitual associations dominant over sense, as in "The stars and *stripes* will shine to-night"; also a weak appreciation of sequential relationships and language form, as in "She *could* if she will," "The boy who *studied* hard will succeed," etc. The meaning of a simple mixed sentence like "people are many candy of fond" is not grasped by K because he is unable to profit from logical cues. He sometimes reacts to pictures by descriptions rather than interpretations because he sees merely parts without grasping the whole they compose. Subtle meanings, whether of language or pictorial representation, are lost on him. The gulf that separates him from Millet is as enormous as that which separates him from Shakespeare. In no intellectual activity that involves the "elaboration of parts into their worth and meaning" (Ebbinghaus) could he possibly excel. "Two and two" as numbers he can put together by the simple laws of habit: "two and two" as parts of a more complex situation will not combine.

In comprehension K fails equally with simple cause and effect relationships in nature, human relationships, and the rationalization of custom. Why the deaf should also be dumb is as much a mystery to him as why the rainbow is many-colored. New York is the largest city "because it covers such a large area." Why honesty is the best policy, why women and children should be saved first in a shipwreck, why marriage licenses are necessary, involve issues too subtle for him to grasp. Although his inferior powers of comprehension render him incapable of real morality, his moral life, measured by the ordinary standards, appears to be quite normal. He is honest, and considerate and not likely to commit bigamy or marry without license. He follows custom but can not see beneath it or behind it. He is about as likely to be a moral reformer as to be a philosopher or poet or inventor or scientist.

Closely associated with this weakness of comprehension is his inability to interpret fables, which usually bring either a comment in terms of the concrete situation or else a generalization which is beside the point. He grasps crudely the general trend of the story, but is insensible to the thought fringes which give it meaning. He is able to imagine the objects and activities described, but taken in the rough such imagery gets him nowhere. It is no wonder, therefore, that he should

match as equivalents proverbs of the most diverse meaning, for proverbs are generalized experience expressed in highly figurative language. K's moral life will never be integrated by principles of action derived from experience. It is more likely to consist of rule-of-thumb behavior. And if he can not generalize his own experiences he is not likely to read much meaning into the behavior of others. He is not likely to develop that intuitive appreciation of the motives and attitudes of others which are necessary for the exercise of leadership. He will make as little headway in understanding the universe of personalities around him as in understanding the laws of gravity, the properties of the atom, the theory of evolution, or the canons of poetry.

Striking examples of the poverty of K's intellectual resources are seen in the various tests of association. Of the dozens of words in his vocabularly which rhyme with *spring* he could not think of one. During the last minute of the sixty-word test he was able to name words only at the rate of 7 in a half minute. Analogies involving concrete objects he can sometimes complete correctly, more often not; but his response is not often wholly irrelevant. *Arm is to elbow as leg is to*—he completes with "abdomen"; a part of the human body, but not the part called for by the logical relationships given. In naming opposites he sometimes loses sight of the goal and responds with a synonym, as in weary—"tired"; stale—"old." In other cases he responds with a word which is frequently associated with the stimulus word in everyday phraseology, as cheap—"goods"; never—"will." Still other responses are either slightly inexact, at best—"poor," or else almost but not quite irrelevant, as top—"tail"; horrid—"mild." Both the low "frequency" of the Kent-Rosanoff response words, and the slowness with which they are given, indicate a lack of variety in concept interconnections, with consequent poverty of verbal associations. As Binet might put it, K's ideas lack direction, are not fruitful, and do not multiply. They are inert and lack valence. The result is intellectual sluggishness and haziness. Our subject will never draw hair-splitting distinctions; he is even incapable of quibbling or making puns.

An essential aspect of the higher thought processes is the ability to associate ideas on the basis of similarities or differences. This ability is involved in such diverse mental acts as the understanding of simple figures of speech, the appreciation of poetry, the scientific classification of natural phenomena, and the origination of hypotheses of science or philosophy. Intellectual superiority is especially evidenced in the ability to note *essential* likenesses and differences, as contrasted with those which are superficial, trivial or accidental. It is here that K displays one of his most characteristic weaknesses. An apple and a peach are alike because they have a skin; iron and silver, because they are heavy; an animal and a plant, because they have hearts; a snake, a cow and a

sparrow, because they have a tail; grass, cotton, tree and thistle, because they are green. Other similarities given are far-fetched or inaccurate. A hat and a coat are alike because they are gold rimmed; a rose, a potato and a tree, because they have a skin or heart. There is little logical connection among K's concepts; they do not light up one another; they have not been subsumed under classes; they lack definiteness of content.

All of this is again brought out in the vocabulary test, which in a remarkable degree is a test of one's ability to distil concepts—from experience. Mere schooling affects it a little, but very little. Although K has attended school fourteen years, his vocabulary is less than a year beyond the standard for average children of his own *mental* age. Both the school and the cultural influences of a superior home have failed to give him an understanding of such common words as civil, brunette, bewail, priceless, disproportionate, tolerate, shrewd, repose, character or reputation. His definitions are occasionally infantile in form (given in terms of use, etc.), but are more often vague, or grossly inaccurate without being wholly irrelevant. For example, lecture means "to be taught"; ramble, "to go fast"; conscientious, "very good in his work"; brunette, "white"; tolerate, "to get away from." All of these words he has probably seen or heard scores of times, but he has failed to grasp their meanings because of inability to analyze the situations in which they have appeared.

Summing it all up we may say that K responds normally to simple situations directly sensed, and that his inferiority is chiefly evident in responses involving intellectual initiative, planning, range and flexibility of association, analysis of a situation into its elements, alertness, and the direction of attention toward the significant aspects of experience. Most of all, K is stupid because he is not adept in the formation and manipulation of concepts; because he is unable to master the intellectual shorthand of general ideas.

What is the practical bearing of the above facts on K's vocational outlook? While an exact answer to this question is at present not possible, a few tentative predictions may be ventured. K is at present performing the duties of a regular clerk in his father's store, apparently with success, but it is unlikely that he will ever be able to manage a business of any considerable importance. That he will ever succeed his father in the local bank is hardly in the bounds of possibility. Perhaps he will know how to get credit and how to grant it with fair discretion, but he will never understand the principles of credit by which banking is carried on. He may learn how to purchase bonds, to clip coupons, and how to save his income; but he will never know what a bond is. That he could become a minister, lawyer or doctor is unthinkable. He will never engage in theological disputes or concern himself about

principles of artificial immunization. On the other hand, a hundred kinds of skilled or at least semi-skilled work are open to him. As far as intelligence is concerned there is no reason to suppose that he could not be a reasonably good baker, barber, bricklayer, butcher, carpenter, drill sharpener, freight checker, game warden, glass blower, harness-maker, horse-clipper, jail-keeper, joiner, lathe-hand, policeman, professional baseball player, plumber, prize fighter, peddler, railroad brakeman, riveter, roofer, section boss, soldier, street car conductor, timer, truckman, valet, weaver or yardman. There are doubtless also innumerable kinds of routine clerical work in which he could do well. For all we know he may become a successful business man, but this is unlikely unless through the shrewd choice of assistants or marriage to a capable woman.

Whatever he does for a living, K may be expected to become a citizen of average respectability, though he is not likely to be elected to important office or to play a leading rôle in the affairs of his community. As a voter, he will never glimpse the fundamental problems relating to taxation, tariff, government ownership, systems of credit, education, labor or capital. If he ever concerns himself at all with political matters, it will probably be as a loyal adherent to his party and a devout repeater of its catchwords.

CERTAIN UNITIES IN SCIENCE

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THAT the several sciences taken as a whole form one science is a proposition which has often been urged, sometimes apparently as an article of faith and sometimes as a reasoned conclusion. To an individual who holds, with nearly religious fervor, the doctrine that the universe is one and that the truth of science asymptotically approaches the absolute truth about the universe, there can be no doubt of the oneness of all science; there is no room or opportunity, except through error, for that diversity which destroys the oneness of the whole. To an individual of such an outlook it may be almost or quite an article of faith that all science is one. But to him whose universe is not so tidy, in whose thought there is the ever-present possibility that after all we may be building on insecure foundations, the assertion of the unity of science can be made only on a reasoned analysis of its characteristics and on the established fact of the presence in it of such dominant qualities as bind the whole indissolubly into one. To exhibit such elements and to show that they have such qualities is a task of large proportions, for beyond the possible achievements of a single paper. Our purpose is the more modest one of exhibiting certain common elements, certain unities, in science as a whole and of partially analyzing the way in which their presence affects the character of scientific truth.

The unities in science, however far-reaching, can never be absolute. Whatever is common to two domains of knowledge appears in each of them colored by the dominant light of the particular discipline. Perhaps the most obvious unity of all is that of experimentation and observation; its presence in natural science is almost universal. But in mathematics it is partially obscured from view by a universal insistence upon logical connection in exposition, so that the processes of experimentation and observation which were employed in discovery are not in evidence in the finished product. In the case of empirical theorems stated as conjectures (such as have occurred frequently in the history of the theory of numbers) we have the most notable partial exception to what is the general rule. The results conjectured are genuine empirical theorems. Mathematics differs from the natural sciences in refusing to accept these conjectured theorems without a logical demonstration. In thousands of cases it has been observed,

for instance, that an even number is a sum of two primes and no even number is known which does not have this remarkable property. It is conjectured to be true that every even number is a sum of two primes. But, as long as a logical demonstration is wanting, no mathematical memoir or treatise will assert its truth. Such an ideal of carefulness is possible as a practical ideal for the control of actual mathematical exposition; and, since it is possible, we insist upon it absolutely. But, from the greater complexity of its problems and the nature of the truth with which it deals, natural science can not insist upon such perfection of logical form but must rely upon incomplete induction from particular observations to general laws and their subsequent experimental verification either directly or through the intervention of their consequences. The nearly universal unity of experimentation and observation is seen in varying colors in the different sciences.

Probably a more important, if less obvious, unity is that of invention or creation. This is most clearly in evidence in pure mathematics; but an examination of it as it appears there leads to the judgment that it is perhaps dominant throughout all science. There are those who wish to have the universe so tidy that nothing actually novel could happen in it, that happening would be impossible, that every event should be a mere consequence of the events which have preceded it. But there are others who would not object to the surprises and thrills of true novelty, who would not be disconcerted by the conclusion that a law reached inductively by the mind is essentially a creation of the mind, made (to be sure) for the purpose of relating in thought a class of observed phenomena, but none the less a veritable creation or invention. The whole matter turns on this question: Are the laws obtained by induction found in nature and dictated entirely by nature, or does the mind in some manner impose its own bias upon them? It appears that we are forced to the latter conclusion, particularly when we see the dominance of a general theory like the atomic theory or the rapid inroads of such a one as the theory of relativity and reflect how these were conceived in the mind before there existed any empirical evidence for them. In such cases as these the mind has either imposed its own bias upon the laws of nature or it has had an uncanny foresight of them before they appeared in experimental science. The former seems to be the more natural and justifiable hypothesis.

There is much to be said in favor of the thesis that natural science should be considered a construct of mind rather than a paraphrase of nature wrought out by the mind. The processes of invention are most in evidence in the formulation of hypotheses, and most clearly when these are based on only a few observations. There is no experimental proof, and perhaps in the nature of things there can be none, for the

hypothesis of the conservation of energy on which all modern physical science is based. This seems to be a law imposed by the mind for its convenience but without direct experimental support; at best it is contradicted by no experimental fact.

But invention seems also to be present in the process of experimentation. The experimenter is not a merely passive recipient. He is active in directing the course of events. He invents phenomena which would be non-existent without his guiding influence. He gives attention to what he wills and ignores other things. He will not see all that happens, nor will he record all that he sees. He selects before he places on record for the examination of others.

The principle of direct causality is almost universally held to underlie all natural science; the principle of inverse causality is also generally asserted as true, but with less confidence in the assertion. If the principle of causality exists at all in mathematics it must be in some greatly attenuated form. It can hardly be said that the triangularity of a Euclidean triangle is a cause having as an effect the proposition that the sum of the angles of the triangle is equal to a straight angle—unless one thinks of the cause-and-effect relation as having here a quality peculiar to mathematics. But in the natural sciences the principle seems to rule supreme. In some of them it is employed mostly in the direct sense, as in physics where one generally utilizes it for proceeding from the cause to the effect; in others the principle of inverse causality is more often in evidence, as in geology where we infer the past state of the earth from its present state. If the principle of causality affords a unity in science it can do so only on the assumption of at least the three well-distinguished forms which we have just mentioned. Moreover, however one approaches it, it involves him in speculative difficulties from which it is hard to extricate himself. It is a severe, if not an impossible, task to adjust his conception of the principle and his practice in its use so as to avoid just criticism and his own dissatisfaction with it.

The difficulties which we have seen here in these cases are probably to be found, singly or in combination, in the case of most of the more obvious unities in science. The element of unity may fail to be as well marked as we like throughout the whole range of the sciences, as in the case of the unity of experimentation and observation; or it may be of such character that people can not be brought to general agreement about it as in the unity of method involved in the hypothesis of invention or creation; or it may lack somewhat in oneness, as in the case of the three forms in which the principle of causality appears. The main object of this paper is to discuss certain actual or possible unities not having these defective qualities.

The complexity of nature is great beyond our ability to understand

or perceive. The material universe is too rich in form and the fullness of phenomena for us to reach the whole extended complex in a single grasp of the mind. The extreme variety of kinds of objects, the multitudes of individuals of a kind, their almost innumerable relations in time and space, the ramifying causal connections among them and their mutual dependencies, their diverse relations to our own life and thought, and the hidden things in them which our organs of sense are unable to perceive even when supported by the powerful instruments of science—all these tend to produce a complexity in the presence of which we are helpless so far as logical organization of all impressions is concerned.

Even in the realm of those objects of thought which are constructed by the mind itself there is too much diversity for us to contemplate the whole at once if we are to do anything other than make glib general statements unsupported by anything more than a certain appeal to the imagination. It is evident that the mind is able to contemplate successively the elements of a range of objects of thought far too vast to be embraced in a single encircling mental act. This is true not only in general but also in the case of such extended ranges as pertain to a single domain, as for instance that of mathematics or that of philosophy.

Two quite distinct worlds about which we should have exact information may be conceived separately; the world of matter and the world of logical thought. Let us examine the two things presented to our consideration by the physical phenomena of matter on the one hand and on the other hand that special domain of logical thought which is embodied in mathematics. There is a very wide range of mathematical knowledge apparently unconnected with the properties of matter. There are physical properties of matter, so complicated that mathematical methods are still powerless in their presence. Each of these domains is vast in its extent. There is a relatively narrow strip on which the two overlap, the properties of matter yielding themselves to mathematical formulation and the mathematical truth seeming to have its concrete embodiment in the properties and phenomena of matter. The existence of this common region of the two things apparently so widely separated has arrested our attention and has directed it so forcibly to the striking parallelism that we have sometimes felt that we have in it a fair measure of evidence for believing the whole universe to be rational. So far this conclusion has too much the appearance of a pious wish and two little the character of a demonstrated result to justify our confidence in it. The relative narrowness of the common region of the two is rather disconcerting if we examine it closely. Even if all physical relations should be reduced to mathematical formulation we would still have far to go to

reduce all phenomena to rational order and to find logical connections among all their parts.

This diverse character of the most widely separated elements of physical and of mathematical science is one evidence of the necessity for breaking up into parts the total body of material concerning which we seek to attain exact and permanent knowledge so as to bring it within the range of such methods as we are able to conceive and employ in one connected investigation or analysis. But if we break this material up into parts it is only by ignoring certain connections of importance, only by making abstraction of elements which may be omitted for the intended partial view but are essential to a complete understanding of the whole.

The general situations actually presented by nature or by thought are too complex for us if we are to gain permanence or invariance in the conclusions which we reach. We have to create ideal situations where we are more at home and over which a restricted range of method will carry us with safety and with conclusions of sufficient penetration to have abiding value. We have to adapt our procedure to the strength of tool afforded by our minds when brought to their state of highest effectiveness. With a more penetrating insight less abstraction would be necessary; but only omniscience would enable us to conceive and handle at once the total flux of nature and thought. We have to work subject to the restrictions of our essential limitations.

This process of abstraction has been carried further in mathematics than in any other science, having attained a place of importance there long before its primary character was recognized in other disciplines. Every organism possessed of locomotion has to deal with the problem of space relations, and particularly an architectural animal like a beaver or a man. Long experience in construction and measurement will give rise to a certain body of empirical knowledge and rule-of-thumb methods for making standard constructions. To such a state of advancement the knowledge of space had already attained among the ancient nations of the Orient and particularly among the ancient Egyptians. But their progress was intercepted by their inability to make needful abstraction of the essentially irrelevant and to concentrate on those properties which afford the essential elements of geometrical form as such. They could only imperfectly conceive a triangle as anything more ideal than a piece of land of a certain outline or a flat stone of a certain shape.

As long as the problems are conceived as those of the space relations of material objects there is present to thought a large disturbing element which successfully turns the attention away from what is essential. In order to construct a theory of the space relations of objects it seems to be practically necessary to do a more ideal thing

first. Before one can make serious progress in the way of definite conquest, one must abstract from the general complexity of the situation and attain to a new one relatively much simpler. In fact, not only in the study of properties of geometrical space but also in many domains of science it is necessary to create a new situation having certain analogies with the actual one of nature but being so much simpler that we are able to grasp the interrelations of all its parts.

This idealizing of the problem of space relations was first effectively achieved in the geometry of the ancient Greeks. They were able to get away quite completely from the material triangle and to conceive the ideal triangle defined by certain essential ideal properties. Likewise they were able to make abstraction of what was not necessary to the purposes of a pure geometry in the various lines and circles and other figures which they wished to consider. This new attitude toward the subject matter of the theory of geometrical space allowed an altogether unforeseen extension of knowledge; geometry came into being in one of those forms which stand as part of the modern theory. By abstraction of unessential elements the mind came to behold a much simplified object of thought and analysis a knowledge of whose properties gave the needful insight into the space relations involved in normal everyday experience.

For a long time this body of geometrical truth stood apart from all other knowledge, separated by qualities of generality and ideal conception from all other doctrines whether of mathematics or of some other discipline; but, after a time, algebra began to assume a like position of separate completeness and it existed so until algebra and geometry were brought together by the invention of analytical geometry.

The abstraction of the unessential in the study of space relations, difficult as it was and effected only in relatively recent times, seems to have been the easiest large abstraction for the human race to achieve. This was probably due to our intimate racial acquaintance with the space of experience during the whole period of our evolutionary history and to some peculiar adaptation of ourselves to the understanding of spatial relations. That our long drawn out experience with it is not in itself sufficient to enable us to fix attention upon the essential elements and to understand their relations is shown by the fact that we have been quite as long acquainted with the weather as with space relations and that we have not yet been able to reduce to the form of an exact science our knowledge of its daily changes—unless indeed we have been hindered in such progress by essential changes in the character of the weather during geological ages while the relations of space have been an invariant element throughout our experience.

The fact that mathematics first succeeded in making these large

abstractions from the complexity of the environment in building up its body of doctrine and that is today relative the furthest advanced of the sciences raises the question as to whether there is a general correlation between the state of advancement of a science and its success in forming appropriate abstractions. The just conclusion seems to be that no science is far advanced until it has first succeeded in isolating by abstraction a large body of material, conceived ideally apart from the matrix of its environment and possessed of such essential properties as make it possible to pass from the conclusions of this ideal science into the actual complexity of phenomena with a better understanding of important phases of the latter than is otherwise possible.

In meteorology, where successful abstraction is exceedingly difficult, we find a relatively small body of securely achieved truth. The same is true in our study of industrial organization and of the complex phenomena of the social relation. But if we turn to the work of the astronomer in celestial mechanics, where nature herself almost made the abstractions for him, we find a science relatively far advanced and one which achieved its position of preeminence early in the modern era.

Under the inspiration afforded by the laws of Kepler Newton meditated on the question as to the ultimate law of nature upon which the properties of the planetary orbits depend; and he was led to conceive, and establish by geometrical reasoning, the principle of universal gravitation and the law that the force of attraction between two material particles is directly proportional to the product of their masses and inversely proportional to the square of the distance between them. These discoveries of Newton condensed an almost immeasurable volume of thought into a compact and simple formula, bringing the theory and observation of past ages to a focus from which new lines might diverge in many directions. Laplace undertook to draw out the consequences of the laws of Newton, his purpose being to "offer a complete solution of the great mechanical problem presented by the solar system, and to bring theory to coincide so closely with observation that empirical equations should no longer find a place in astronomical tables." His success in both respects brought him very close to his lofty ideal.

The "Mécanique Céleste" of Laplace holds a unique place in the history of science. It was the first instance in which an extensive unified and logical theory had been developed for a large class of observed phenomena. A very few fundamental principles lay at the basis of the entire work, owing to abstraction of unessential details; and it was developed from these principles in its entirety solely by mathematical processes, this logical procedure being rendered possible

by the essential simplicity of the ideal situation. In such a body of truth there is something esthetically satisfying in a high degree. It could not fail to have a profound effect on the development of thought.

The cosmical and subsequently many terrestrial phenomena having been explained, it was natural that Newton, and still more Laplace and his school, should attempt the explanation of molecular phenomena by similar methods, importing into molar and molecular physics the astronomical view which had arisen in mechanics. This celestial mechanics became the model for the exact sciences. Men sought to give to other theories an equally beautiful and logically consistent form. The start from a few principles, easily enunciated and readily comprehended; the forward march of the theory into new fields, comprising in the range of its explanation an ever-increasing portion of observed phenomena; and its ultimate comprehensiveness in this respect—these things gave it a hold on the imagination. It thus became a profound factor in the development of the whole of physical science in its mathematical form. The cold touch of exact thinking and the calculating mind, both products of the method of abstraction in the development of scientific truth, have proved to be the spell by which knowledge has been found, new sciences have been created and a novel trend has been given to the development of thought.

Perhaps I may digress widely enough to indicate how the precarious character of scientific advancement is indicated by some of the matters now in consideration. Suppose that our earth, instead of being one of a few planets moving around a single sun, had been one of several satellites of a large planet moving about the center of gravity of a double star; thén it is clear that the facts of astronomical observation which would first have pressed themselves upon our attention would have been much more complex than those of our actual system. When we consider the long period of time which it required the race to unravel the intricacies of the much simpler system of which the earth is a part and the uncertain and haphazard way by which it took the necessary steps, we see that there is room for grave doubt as to whether we would ever have conceived a suitable explanation and whether (having missed such a guide as this) we would be in a position successfully to attack or even to conceive the problems of natural science. Our progress has been made under the inspiration of the ideal afforded by astronomy on account of a success due to abstractions to which the nature of the observations pointed the way. Could we have ever conceived such an ideal if we had been confronted with a much more complicated astronomical system? And could we have already built up, or would we have ever been able to build up, a body

of science comparable to that which we possess today? Certainly the answer can not be a confident affirmative.

Natural science and mathematics are not the only domains of thought in which the principle of abstraction is prominent; it appears also in speculative philosophy. But its relation to the latter is quite different from that to the former domain. In science we are quite willing to admit abstraction frankly as a universal characteristic which is necessary on account of the limited character of the intellect. But the philosopher desires to get away from it as far as possible. He wishes to embrace in his system an ever-widening range of material; and he would be most pleased if it might be ultimately comprehensive. He knows that he has not attained to such an ideal and probably never expects to; but he still feels a certain sense of uneasiness when he finds a body of truth quite unrelated to the system by which he has brought things to order in his own mind.

But in art and literature the matter is quite different. Here the intention is to contemplate at once the whole stream of life and existence, at least so far as to have no purposed exclusions. Here one deals with the actual complexity of events and even with the character and emotions of individuals. One does not state theorems; one does not announce universal laws; one does not reach rules-of-thumb for doing mechanical things; one does not even find general principles upon which there is universal and permanent agreement nor those by which one may have precise guidance for conduct in any given situation; but one does reach permanent conquest in the creation of things of enduring beauty; one produces lasting values for the emotional life even if one does not increase the body of exact knowledge.

From the foregoing considerations it appears that the method of abstraction, as an active means for clearing off the ground and an active support to the consequent investigations, is common to all science and is characteristic of science. It is therefore one of the important characteristic unities in scientific method. We find it necessary to isolate one subject from another by abstraction in order to avoid being smatterers. We reduce our serious problems to ideal abstractions because no deep-lying problem can be solved without reducing it to abstractions. If we do away with them we do away with mathematics and logic and natural science. They have thoroughly justified themselves through the marvelous conquests of modern science which they have so effectively supported.

But these abstractions are not without their dangers. It has been said that the supreme fallacy of the academic mind is carefully to make abstractions and then straightway forget that they are abstractions. "The expert in the conceptions belonging to one field of knowledge legitimately solves the problems of that field in their terms. But some-

times he forgets that these are very special and limited notions of truth, applicable only to that one field. He ignores that his science is only one abstracted aspect of concrete life, separated from other aspects of life only for the sake of specialization of labor. Ignoring this, he attempts to solve the problems of other fields with his own field's special concepts. Thus, a biologist sometimes endeavors to reduce all psychology to biological concepts; or an economist to reduce all moral values to the special values of the economic world."

Perhaps, for the sake of unity in point of view, one may be allowed to treat, as resulting from a certain form of the method of abstraction, a quality of the mathematical formulation of the laws of nature which first appears explicitly in the general Einstein theory of relativity. This is not the place to give any of the technical developments [1] belonging to the latter theory. But it is a matter of general scientific interest to indicate the character of a new ideal for the form of scientific laws which was first insisted upon in the investigations of Einstein, particularly as it can be successfully described without any of the heavy mathematical machinery which is essential to a detailed development of the theory. This ideal emerges in connection with the analysis of the now celebrated principle of equivalence, which we may enunciate as follows: A gravitational field of force is exactly equivalent to a field of force introduced by a transformation of the coordinates of reference so that we can not by any possible experiment distinguish between them.

The notion of transformation of coordinates of reference, which appears here, is quite essential to an understanding of the quality of mathematical formulation of laws which we wish to explain. Perhaps we may best approach the matter by conceiving a geometrical curve fixed in the space interior to a given room of four walls meeting at right angles. If we take the floor and two adjacent walls to be a system of reference by means of which to locate the positions of a point in the room, then we can uniquely define the positions of a point on our curve by giving its distance from the floor and from each of the two walls selected. If the point moves along the given curve then the numbers expressing these distances will be related according to a law determined by the shape and position of the curve; these three variable numbers will satisfy certain equations of condition. If we used the ceiling and the other walls as a system of reference we should in general obtain different equations of condition for the same curve. Those would be further modified if we chose for reference system some other set of three planes mutually perpendicular to each other, and especially so if these planes should be oriented in some new directions.

[1] The reader interested in these developments will find them in the second edition of my "Theory of Relativity," Wiley & Sons, 1920.

It is clear that these changes in the system of reference have in no wise affected the properties of the curve itself, though they have constantly modified the mathemaitcal expressions by means of which we may most compactly and most completely describe the curve and its position. Let us for a moment forget these systems of reference and study the curve itself by passing along it from point to point. Two characteristics will force themselves upon our attention; the amount of bending of the curve as we pass along it, its curvature; the amount of twisting of the curve, its torsion. These are intrinsic properties of the curve itself capable of representation at each point by definite numerical values. These numerical values can be expressed in terms of the three distances pertaining to any given one of the systems of reference mentioned above; it turns out that definite rather simple formulae exist for expressing the curvature and torsion in terms of the named measurements. Since these describe intrinsic properties of the curve their values must be unaltered by the transformations of variables due to the changes of the system of reference; that is, they must be invariants of the transformations.

It is seen therefore that the analytic expressions for the curvature and torsion are unchanged in form and in value as we pass from one system of reference to another. It can be shown that they completely determine the intrinsic properties of the curve. Then we have in them a complete mathematical description of the intrinsic properties of the curve in a form from which we have abstracted those pecularities which belong to the special system of reference by means of which we described the curve and its position in the first place. This sort of abstraction is of frequent and important use in mathematical investigations. It affords one of our methods of excluding from consideration those things which are irrelevant to the central purpose of the investigation and of fixing attention upon those things alone which are unaltered by, or are invariant under, the transformations permissible among the elements in consideration. A similar but extended use of invariants is a central feature of the Einstein theory of relativity.

Two rather considerable extensions of the method are necessary in order to realize the situation in the Einstein theory. The first has to do with a generalization of the system of reference. In what we said above we contemplated the location of a point always through the measurement of its distances from three planes. Now we wish to replace the three planes by three warped surfaces, perhaps twisted and corrugated and bent into a great variety of shapes and restricted only enough to allow us to utilize them successfully for the location of points in space. By means of these we are to describe the space-configurations with which we have to deal.

The other step which we wish to take is that in connection with the

introduction of time into our system. We can not well develop the mechanics of three dimensions by means of what is simply static in three dimensions; and the introduction of motion and the analysis of velocities and accelerations require the use of the time variable. Moreover, we are not to think of time and space as independent but are to consider the two together as furnishing the four-fold extension of a time-space continuum. This gives us, of course, a space of four dimensions; and in this space of four dimensions the movements of the natural world are represented by static figures. In this space of four dimensions we are to choose as a system of reference four warped three-dimensional spaces by means of which the location of points in this four-dimensional space shall be defined.

With these conceptions in mind we shall undertake to make clear the nature of the central ideal upon which Einstein insists. He wishes to have the laws of nature expressed in such form with respect to this four-dimensional continuum that there shall be no change in the form of these laws when we pass from one of these systems of reference to another; the statement is to be an invariant one when all quantities involved are changed in accordance with a transformation which carries us from any one of these systems of reference to another; let us say for convenience that the laws are to be stated in covariant form. When we have put them into such form we have abstracted from the statement whatever pertains to the particular system of reference employed.

It is a grave question whether the laws of nature are capable of formulation under such radical restrictions; and an affirmative answer can be maintained only after a searching examination. The best way for a just trial of it is to employ one of the best established and most satisfactory laws; none could be more suitable than the Newtonian law of gravitation. Hence one of the first efforts of Einstein to test out the theory was made in the attempt to apply it to celestial mechanics. It turned out that the Newtonian law of attraction does not accord with the ideal of covariance of the laws of nature; it is not capable of expression in precise covariant form. Is the principle then to be surrendered? Not without further evidence; it may be, after all, that the law of Newton is not exact.

The next task of the investigator, then, is to inquire whether there is some slight modification of the Newtonian law which will bring it into covariant form without making it false to experimental fact. It was not difficult to show that the Newtonian law was a very close approximation to a law which is indeed covariant; and the latter was then taken to be the law which should replace the Newtonian law.

Questions which force themselves upon our attention then are the following: Does the new form of the law have any definite advantages

over the old? Can it be subjected to an experimental test to determine which of the two approximate laws is the correct one? Now it happens that the Newtonian law has long been known not to agree exactly with observation in the matter of the motion of the planets. In the case of Mercury the discrepancy is altogether too great to be attributed to experimental error. If the law of Einstein is applied to the problem it accounts for all these motions within the limits of experimental error. Here it scores its first victory over the Newtonian law.

A second crucial test of the theory is offered by its prediction of the deflection of a ray of light which passes through a strong gravitational field. This prediction was tested by observations made independently at two stations during the eclipse of the sun of May 29, 1919. The problem was to determine the amount of bending in a ray of light passing near the sun and hence through its strong gravitational field. The values for the deflection obtained at the two stations are 1.61 and 1.98 seconds of angular measure, resulting in fairly good agreement with the predicted value of 1.74 seconds of angular measure.

The ideal of the covariance of the laws of nature as a practical ideal thus passes successfully its first test, and indeed in a dramatic manner. That Maxwell's electromagnetic equations may be reduced to a covariant form and hence that all electromagnetic phenomena described by them are in agreement with the principle of relativity may be readily shown; and thus the ideal of covariance meets a second fundamental test. There is no known case in which it must certainly be surrendered, though there is an important one which remains still in doubt (see p. 105 of my "Relativity" already referred to).

If all the laws of nature can indeed be expressed in covariant form we have through this fact brought to light a certain profound unity in the laws of natural phenomena, one which will surely be satisfying in an esthetic way to every one who contemplates it with understanding.

We have insisted upon the importance of abstraction as a means of bringing the complexity of the phenomena contemplated within the power of the mind for purposes of systematic analysis. There is also another quite as important reason for making abstraction of certain elements involved in the general complex of the environment; and that is the necessity or desire to find a range of phenomena and objects of thought about which there can be at least a fairly good agreement. The propositions concerning which there is general agreement among competent persons are said to have an objective validity; others are called subjective. Upon being pressed for a definition of "objective" as employed in the phrase "objective character of science" the scientist sometimes asserts that the objective is that which pertains to the world which is external to ourselves or to the world of objects whose essential character is not affected by the subject who contemplates it. But if he

is further pressed for a criterion to determine whether a given thing is objective he has to return to the conception of the objective as that about which there is general agreement among competent persons.

It may be objected that this definition describes merely that which is invariant and that we ought to refer to the invariant character of a scientific thought rather than to its objective character. But it seems to me that "objective" as applied to things of science has no scientifically definable sense except that which rests upon the idea of invariance, at least if one admits (as I think he must in matters of science) that a definition should be so stated that it is theoretically possible to determine whether or not a given thing meets that definition. Moreover, "objective," as the word opposed to "subjective," seems to be well suited to convey the connotation desired. At any rate, it is our purpose to proceed from this as a tentative definition to a more penetrating analysis of the ideal of the objectivity of science, an ideal which can be attained in any particular situation only by excluding from consideration a large portion of the attendant circumstances.

Regardless of the way in which we frame the definition it is agreed that an essential quality of scientific truth is its objectivity. It must depend solely upon the object studied and not upon the subject who investigates. It must be impersonal, having validity independently of the temperament or the peculiar disposition of the individual who reports it. What do we mean by such a demand as this? What can we mean? It is clear that the investigator can not be a mere passive recipient of impressions, a tablet on which nature registers her characteristics. He must be active in several ways; he chooses the things to which he shall direct his attention, his reason or intelligence is an essential element of the registering apparatus, and he is restricted by the limitations of his sensory equipment. He can obtain and convey only that information which his nature fits him to acquire and report upon. The demand for objectivity can not be a requirement that he shall do otherwise. But it is a call for the exclusion of the subjective element, the element which is peculiar to his individuality; and this exclusion is to be brought about by such comparison of his report with that of others as shall make it possible to determine those elements which are independent of his individuality.

But it is clear that such a procedure affords us no means of excluding what is peculiar to the human race as such. This would require the existence of many cognate races of widely different social characteristics by the comparison of whose scientific conclusions we could eliminate that which is peculiar to each, retaining as a residue only that which has objective validity relative to the group of races as a whole. Such a procedure, if the means were at hand for realizing

it, would carry us one step further toward the far-off goal of absolute truth. But we shall have to be content to work without such means of removing from our body of knowledge the elements which are peculiar to our racial individuality. This affords no occasion for dissatisfaction, since the only use we have for our science is that which can be realized by human beings. But it is sufficient to assure us that we have no means of reaching absolute objectivity in our science, if such a thing is indeed conceivable.

The conclusions or observations which we shall admit as having the required objective validity are those which are invariant in the sense that they are reached by all normal human beings who investigate properly the pertinent matters. We can not get along without the qualification of normality of the individuals admitted to the group for which we seek the invariance in consideration nor can we omit the requirement of the proper investigation of pertinent matters. It is hard to see how we can altogether remove subjective considerations from the process of determining when these conditions are adequately met. We can not avoid the conclusion that the highest objectivity realizable in practice falls far short of the quality of being absolute. The conclusions and observations which have the requisite objective character are those only which are invariant for a properly determined group of individuals; and the determination of the group to be admitted can be effected only by the members of the group, since there is no external intelligence that sets them apart.

It is convenient to distinguish two types of objectivity, as here defined, differentiated as to range of time through which exists the group of individuals by means of which each is realized. We may call the one contemporary objectivity and the other historical objectivity, the former being asosciated with a group living contemporaneously and the other with a group scattered through a long period of time, say the whole historical period. All the general truth which is universally approved in a given age among people properly qualified to form a judgment upon it possesses this contemporary objectivity. That which meets with acceptance from age to age with unchanging uniformity has the higher order of historical objectivity. From the truth possessing contemporary objectivity that and that alone survives to attain to historical objectivity which impresses itself alike upon the peoples of succeeding ages.

The subjective character of matters of taste is notorious. Even the milder objectivity of the contemporary sort is seldom attained, and always only imperfectly. Universal agreement on such a judgment of values in a given age carries with it no assurance that succeeding ages will concur in the conclusion. Yet there are some judgments concerning matters of art which go far towards exhibiting the qualities of

historical objectivity. There is an abiding unanimity, for instance, in ascribing a high excellence to the finer elements of Greek sculpture. The more magnificent creations of this art impress with their marvelous beauty the people of one age after another; and these all appear to obtain from them a joy of the same general character. It is true that individuals represent this to themselves variously and that they differ greatly when they seek to give an account of the way in which they are affected. But certain elements of the judgment of value seem to be invariant from age to age and from individual to individual. So far as this is true we have a manifestation of objectivity even in these matters of judgments of taste.

If we find thus a measure of objectivity in these things which are usually esteemed to be highly subjective in character, we also find certain elements of subjectivity even in the matters of science and marked elements in some bodies of truth considered objective by those who develop them. Merz, in his "History of European Thought in the Nineteenth Century," a work to which the present author is greatly indebted in several ways, says: "Most of the great historians whom our age has produced will, centuries hence, probably be more interesting as exhibiting special methods of research, special views on political, social, and literary progress, than as faithful and reliable chroniclers of events; and the objectivity on which some of them pride themselves will be looked upon not as freedom from but as unconsciousness on their part of the preconceived notions which have governed them." Thus the objectivity to which these historians have attained appears to be only contemporary in character.

In forming a judgment of the significance of modern science it is important to ascertain the character and measure of objectivity to which it has attained as a whole and to make a classification of it into parts according to the extent of its success in becoming objective. A large portion of what is now current has gained its position so recently and has so forcibly ejected the earlier explanations to make place for itself as to raise a reasonable question of doubt concerning the validity of the whole structure. When theories have changed so constantly, so long and so profoundly, we can not well believe that we have suddenly come to a state of stability. The changes are likely to continue. If they are retarded for a time they will probably break forth later with increased violence. It is not long since we witnessed a period of explosions in the theory of matter and motion; and indeed we do not yet appear to have come to the end of it.

In the midst of this rapid change what permanent truths are to be perceived? Which can maintain themselves through the present generation and achieve historical objectivity through the support of future thinkers? It seems clear that it can not be the theoretical explanations,

except in relatively few instances if indeed in any, at least if the explanation is conceived to carry with it the means of affording a penetrating insight into the phenomena explained. If the theoretical explanations do not abide, what is there left? Simply and solely the account of relations among phenomena, however these are expressed, whether by means of the mere record of observations or through the more powerful tool of scientific theory conceived merely as a mnemonic device and a support to the weakness of the intellect in its deductions. The statement of relations has in many cases attained historical objectivity in natural science; but theoretical explanations have usually suffered change from age to age and the process seems likely to continue.

Mathematical truth, so far as it is expressed in definite theorems, has achieved almost complete historical objectivity. A result once attained abides through the ages. Errors are made with relative infrequency and these are usually corrected with such definiteness as to secure general and abiding agreement. The permanence of result has for a long time been considered one of the essential glories of the discipline. But there is lack of such complete objectivity concerning the character of the truth attained. Our conception of the position of Euclidean geometry in thought and philosophy, for instance, is far different from that of the ancients owing to the existence of the so-called non-Euclidean geometries of relatively recent times.

If we analyze the remoter origins and earlier bodies of thought by aid of the criteria which we are using, we shall find that we can not deny to the proto-science of savages a certain contemporary objectivity even though its explanations are framed in terms which we perceive to be anthropomorphic or mythological. That the "sun is the flaming chariot of the sun-god, driven day by day across the heavens" is an immediate fact of observation expressed in anthropomorphic language; and probably no more was read into this statement of fact than we are accustomed to transport from our theories into our account of what happens during an experiment or formerly into the similar statement that two bodies attract each other. The primitive explanations maintained their place for a long time; and much useful knowledge was acquired through their assistance and much skill was gained in logical analysis before it was possible to prove them insufficient. "A false theory which can be compared with facts may be more useful at a given stage of development than a true one beyond the comprehension of the time, and incapable of examination by observation or experiment by any means then known. The Newtonian theory of attraction might be useless to a savage, to whose mind the animate view of nature brought conviction and helpful ideas, which he could test by experience." We can deny to the savage neither the use-

fulness nor the contemporary objectivity of the proto-scientific explanations which he offered. They were objective to him in every defined sense in which our science is objective to us. If one points out the anthropomorphic element in them, our criticism will at once be hushed by the anthropomorphism of many of our current conceptions, as for instance that of force. If one objects to the mythical element in their thought let him first take up arms against the colossal myth of the ether in the science of the past century and cut off our thought from this fiction of the scientific imagination. As long as we find it necessary to transport into our theories such elaborate creations as that of the ether (brought in without a shred of direct evidence for their existence) we have little room to complain of the thinkers who formed the proto-science of the savage. Measured by the time through which their explanations maintained their contemporary objectivity, the period during which current scientific explanations have held their place is strikingly short.

The objectivity of truth is never absolute, but always relative to a group of thinkers or the age or ages to which the group belongs. We have no means of removing from our knowledge the marks of our racial characteristics or reaching further into our understanding of nature than to those elements which our sensory equipment enables us to perceive. We have to determine with the best standards we may the group of people in relation to whom we shall insist upon the invariant character of truth as recognized. Since at any time in our history future experience is yet to be evolved we can strictly speaking, have only a sequence of contemporary objectivities, as it were, and never a complete historical objectivity. We can have no logically certain means by which to choose securely those elements of thought in any age which make the nearest approach to complete historical objectivity. A subjective element, that is, an element which varies essentially from individual to individual, is necessarily present in every attempt to reach a means of determining what truth has the dignity of an objective character.

The sciences in coming from under the tutelage of philosophy have not completely shaken off the incubus of its unsupported speculations and prejudices. Phenomena are observed through the goggles of philosophical preconceptions, not only in psychology and biology, but also in chemistry and physics, and even in mathematics; and the conclusions or appreciations are affected in various ways and to different extents. In our generation, in the case of physics (the most advanced of the natural sciences) there is going on a veritable revolution in regard to the philosophical preconceptions on which it is based. As evidence we cite the current discussions of space and time and gravitation.

Again the objectivity of a natural science is relative to the character and measure of abstraction through which it was built up and the syntheses by which the separated elements were afterwards brought together and combined into a unity. This process of synthesis can never be carried to completion without the certain loss of objectivity in the resulting knowledge; and as long as it is not carried to completion we have no means by which to be assured that a matter first treated as essentially irrelevant shall not later come into the focus of attention. In fact, this very thing has recently happened in physics. In studying the properties of light physicists were for a long time content to leave out of account the gravitational field as having no appreciable (or even conceivable) influence; but the Einstein theory has forced them to a fundamental revision of this supposition and has led them to conceive of the ray of light as warped out of a straight path by the action of a powerful gravitational field.

The failure of science to obtain completely its universal ideal of objectivity does not diminish our interest in it. Indeed it is rendered more attractive to those of us who are pleased with a dynamic rather than a static world. Truth is never to be set off in tubes hermetically sealed. It is living and hence possesses the universal quality of life of doing the unexpected thing. Its growth is not hemmed in. We may look forward to its continued progress and novelty as long as we who develop it are finite intelligences.

THOMAS HARIOT—1560-1621

By F. V. MORLEY

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THIS year marks the tercentenary of the death of Thomas Hariot, one of the most interesting of the Elizabethan scientists. He was born at Oxford, and went to St. Mary's Hall in times when there were "menne not werye of theyr paynes, but very sorye to leue theyr studye." The students being without fire were "fayne to walk or runne vp and downe half an houre to gette a heate on theyr feete whan they go to bed." In those times the birch was still in the buttery hatch and the proctors stalked outside the colleges with poleaxes for any "schollers" out after hours. Fines that now come from a student's patrimony were taken from his own skin. And in those far-off days in England there still survived the custom of hazing freshmen.

But apparently Hariot did not suffer overmuch from the discipline. At any rate he made somewhat of a name for himself in mathematics—in that subject then still allied to the black arts. Aubrey tells of a contemporary of Hariot's who studied mathematics that he was vulgarly supposed to be a conjuror, and the scout or college servant used to tell freshmen and other simple people that the spirits passed up and down his staircase thick as bees. A jocular mind could have played up the superstition and become another John Dee. Apparently Hariot was too skeptical to believe what would willingly have been credited to him and too honest to gain by what he did not believe. But this is speculation and the only fact to go on is his appointment as a bone fide mathematician with Sir Walter Raleigh.

How this appointment came about is not quite clear. We have for it the authority of Hakluyt addressing Raleigh in 1587 (translated):

> By your experience in navigation you saw clearly that our highest glory as an insular kingdom would be built up to its greatest splendor on the firm foundation of the mathematical sciences, and so for a long time you have nourished in your household, with a most liberal salary, a young man well trained in those studies, Thomas Hariot; so that under his guidance you might in spare hours learn those noble sciences, and your collaborating sea captains, who are many, might very profitably unite theory with practice. . . . [1]

Raleigh, one of the most remarkably versatile men of a time that specialized in versatility, had been collecting experts who would be use-

[1] Peter Martyr's *"De Orbe Novo"* (Paris, 1587). The preface, containing this passage, is by Hakluyt.

ful in his colonial schemes, and two years before this letter of Hakluyt's he had sent Hariot out in the big expedition to Virginia, or to what is now North Carolina. There Hariot stayed for a full year, acting as explorer and surveyor and reversing his previous position in adding practice to his theory. After that year among the savages he came back to England and fell into the society of the keenest minds of his time. For Raleigh had been prevented from going to Virginia and while his argosies were oversea he had amused himself, in intervals of court activities or fighting or retirement to the country, with an "office of address," apparently a sort of institution for the diffusion of knowledge and a liaison center for intellectuals. Whether or not this suggestion worked out in the Royal Society, there were in the group of men several scientists—Warner and Hues are usually mentioned—and into it came Hariot. But it was broader than a scientific society, as it would have to be to keep up with the interests of its patrons, Raleigh and Henry Percy, Earl of Northumberland. It had its literary side, with the leading and outstanding figure of Christopher Marlowe.

All information as to the group is exceptionally tenuous, resting largely on the gossip of contemporaries. But it is pretty clear that the members soon began to discuss religious subjects and it was here that they particularly scandalized the times. Rumors are thick about "Sir Walter Rawley's School of Atheisme,"[2] whose master was said to be a conjuror. The term of condemnation was very loosely used. There is nothing to show that Raleigh or Hariot had views more extreme than perhaps unitarian or deistic ones and there is much evidence that they were religious in a broad and tolerant sense. But they were great personal friends of the scornful and heterodoxical Marlowe. It has been clearly shown by Mr. F. K. Brown[3] that the dramatic poet was a vigorous exponent of extreme heresy and it was the expression of his views in reckless manner that caused the suppression of the club. Marlowe was killed before he could be convicted and probably the dagger saved him from the stake. Raleigh was kept under surveillance, his house searched, his private table-talk examined, and as he says, he was "tumbled down the hill by every practise." But he was too powerful a man to sit still under the cloud. After a burst of eloquence in Parliament on behalf of religious toleration he set forth in an adventurous pursuit of El Dorado across the Spanish Main and cleared his blood by letting some of the dons'.

Hariot, just as much implicated, behaved very differently. It is probable that he went to one of Raleigh's Irish estates and there worked

[2] See F. S. Boas, "*Works of Thomas Kyd,*" (Oxford, 1901), Introduction, pp. lxx ff.

[3] "*Marlowe and Kyd,*" Times Literary Supplement (London) June 2, 1921.

quietly at mathematics until the cloud blew over. We hear no protest from him unless long afterwards to Kepler (translated):

> For things are in such a pass with us, that still yet I may not freely philosophize. Still yet we stick in the mire. I hope the Good God will make an end to these things shortly. After which better things are to be expected. . . . [4]

And when he came again to London towards 1600 he was a man well known to contemporary scientists. He is mentioned in Hues' "*Globes*" (1593-4), in Davis' "*Seamen's Secrets*" (1595), in Torporley's "*Diclides Coelometricas*" (1602). He lived at Sion House, Percy's seat on the Thames near London, from some time shortly after 1604 until near his death in 1621. It was from there that he carried on his correspondence with Kepler on optical subjects and a more familiar and interesting correspondence with various pupils such as Sir William Lower. His purely mathematical work was apparently completed before he went to Sion House. The years there were interrupted by constant attendance on Raleigh and Percy, both confined to the Tower. Such time as he could find he put upon astronomy, but a great deal went to the carrying of books to the Tower when the insatiable Raleigh was writing his *History of the World*, and to similar services for his caged masters. He was with Raleigh up to the end, and present by the scaffold at the execution. He did not survive by long his first patron and his most gallant friend. Marlowe and Raleigh both gone, the third of the triumvirate passed away by a more cruel exit than either the dagger or the axe. He had suffered for a long time from cancer of the lips, and it came to a lingering end on July 2nd, 1621. He was buried in the churchyard at St. Christopher's, the spot since absorbed into the garden of the Bank of England.

* * *

Marlowe, Raleigh, and Hariot—none of the three lived to finish their work. It would not do to say that Hariot was as striking a figure as either of the others; but that does not take all of his tragedy away. He has not been quite fairly treated by posterity. The fault was largely with himself, for he published none of his own work. Most of his mathematics was, as has been said, thought out before 1604 and probably before the change of centuries. A reflection of his teachings is obtained from the letters from his pupils, such as in the passage from Sir William Lower in one dated February 6th, 1610:

> Kepler I read diligentlie, but therein I find what is to be so far from you. For as himself, he hath almost put me out of his wits. . . (I dream) not of his causes for I cannot phansie those magnetical natures, but aboute his theorie which me thinks . . . he establisheth soundlie and as you say overthrowes the circular Astronomie. Do you not here startle, to see every

[4] "*Epistolae ad Ioannem Kepplerum*," Hanschius (1618) p. 380.

day some of your inventions taken from you: for I remember long since you told me as much, that the motions of the planets were not perfect circles, So you taught me the curious way to observe weight in Water, and within a while after Ghetaldi comes out with it in print. A little before Vieta prevented you of the gharland of the great Invention of Algebra. al these were your deues and manie others that I could mention; and yet to great reservedness had robd you of these glories, but although the inventions be greate . . . yet when I survei your storehouse, I see they are the smallest things and such as in comparison of manie others are of smal or no value. Onlie let this remember you, that it is possible by to much procrastination to be prevented in the honour of some of your rarest inventions and speculations. . . . [5]

Lower is accurate as regards the dates of the work on specific gravity; one of Hariot's paper is dated 1601 and Ghetaldi published in 1603. Vieta's algebra came out from 1591-1600, and we may fairly suppose that Hariot's work was contemporary.

It was his "to great reservednesse" and "to much procrastination" that has hindered us from knowing exactly what his work comprised. One attempt was made by his friends to salvage it from oblivion. The "Artis Analyticae Praxis" came out posthumously in 1631, in the same year as Oughtred's "Clavis." The latter was in many ways inferior in originality, in scope, in suggestiveness; but as a textbook it was excellent, small and available. It was moreover a living product of a well-known author, not a work patched up from the manuscripts of a man ten years dead. The "Clavis" had a more direct influence on English teaching; but it is a fair question as to which had the greater effect on the history of research. For the "Praxis" was read by Descartes and every line of Descartes' analysis bears token of the impression. The Frenchman carried to their conclusion, with typical French lucidity and brilliance, things that remained obscure to Hariot's executors. That there are omissions in the "*Praxis*" that Hariot would never have allowed is shown, for instance, by the general impression (fostered by Montucla) that he did not admit negative roots. But manuscripts in the Harleian collection of the British Museum show that on the other hand he was fully aware of them and accorded them equal rights. Such an omission a man of Descartes' genius would fill up and would be fired to more than simple reparation. No attempt should be made to detract from Descartes, except perhaps from his complete originality. It was fortunate that the work fell into such hands, and the fact is regretted only by those who like to think of genius as without a precedent.

As for the book itself, it appeared in a thin folio. Percy had made the publication possible, and the dedication was to him. On the final page appeared the following note (translated):

[5] The letter is quoted in full in Rigaud, "Supplement to Dr. Bradley's Works," (Oxford, 1833) pp. 42-45, and in Stevens, "Life of Hariot," (London, 1900) pp. 120-124.

To Mathematical Students

Out of all the mathematical writings of Thomas Hariot, not without good reason has this work on Analysis been published first. For all his remaining works, remarkable for their manifold novelties of discovery, are written in precisely the same logical style, hitherto seldom seen, as is this treatise: which is entirely composed of all manner of specimens of brilliant reasoning. And this was done with valid reason, so that a preliminary treatise, besides its own inestimable value, might well serve as a necessary preparation or introduction to Hariot's remaining works, the publication of which is now under serious consideration. Of this accessory use of the treatise we have thought it worth while to remind mathematical students in these brief remarks.[6]

The contents followed in Vieta's footsteps, with improvements in notation and some simplification in technique. But the chief thing in the book, and one of great importance, was the bringing over to one side all the terms of an equation and equating them to zero. It was a simple and yet a real step ahead. As Whitehead says, it started the study of algebraic forms. The resolution of an equation of the *n*th degree into *n* simple factors gave immediate rise to the fundamental theorem of algebra. And though there is the real temptation to read into the terse statements what may not have been thought out, the warning against Tennyson's expression

I thowt 'a said whot 'a owt to 'a said

may be borne in mind, and yet much claimed for Hariot.

How much more the painful lips might have said, or might have been recorded if the "serious consideration" above mentioned had matured, is of course difficult to know. It would take very careful work to read, digest, and judge the eight large volumes of Hariot's manuscripts lying untouched in the British Museum. There are more, apparently, at Petworth. They consist of fragmentary calculations, with occasional connected notes on a diversity of subjects—on astronomy, physics, fortifications, shipbuilding, and all the branches then known of mathematics. And yet even a cursory glance will show some gleams of gold. There is a well-formed analytical geometry, with rectangular coördinates and a recognition of the equivalence of equations and curves. There are notes on combinations and the tables of binomial coefficients worked out in both the forms we now call "Pascal's triangle" and "Fermat's square." And there is one page, otherwise blank on which appears

1	1
2	10
3	11
4	100
5	101
6	110
7	111
8	1000

6 "Artis Analyticae Praxis" (London, 1631) p. 180.

This is certainly prior to the usual dates given for binary numeration. There is no guarantee that these things were original with Hariot, and some may be much older. But at least it is an instance of his knowledge. We may take Lower's praise how we will, but there is little doubt that Hariot's executors would have had material as interesting as the preliminary treatise.

More publicity has been given to Hariot's astronomical work, partly because of the dramatic discovery of the papers by Baron de Zach; and the encyclopedias tell how he used his early training in navigation in his observations of Halley's comet with a cross-staff. Sun-spots he watched with the naked eye, though he admits this gave him pain. Both Hariot and Galileo seem to have borrowed the telescope from the Dutch very shortly after its invention and to have used it simultaneously. With the help of his servant and instrument maker, Christopher Tooke, Hariot seems to have supplied his pupils with telescopes and asked their aid in observation. His own recorded observations go back to July, 1609, a month after Galileo's first construction; and partly independently and partly with the knowledge of the Italian he, too, observed the moon, the satellites of Jupiter and later the comet of 1618.

Some time, perhaps, there will be published extracts from the correspondence of the time, for it throws delightful light on the mental attitude of the scientists. Lower's letters, for example, are charming in their naïve statements. In the letter above quoted he begins

> I have received the perspective Cylinder that you promised me and am sorrie that my man gave you not more warning, that I might have had also the 2 or 3 more that you mentioned to chuse for me. . . According as you wished I have observed the Mone in all his changes. . . . In the full she appears like a tarte that my Cooke made me the last Weeke. here a vaine of bright stuffe, and there of darke, and so confusedlie al over. I must confess I can see none of these without my cylinder. . . .

And when he wishes to compliment Hariot in another letter some five months later he says he has done more

> . . . then Magellane in opening the streightes to the South sea or the dutch men that weare eaten by beares in Nova Zembla. . . .

Perhaps this last is not too high a compliment; but when the compliments to Hariot are discussed the truth will be seen of a statement made above. He has not been fairly treated. There are errors on both sides, from Montucla's curt dismissal to the adulation of Baron de Zach. To the latter Hariot's use of the telescope was proof of his inventing it, and a mark of superiority to Galileo. In short, more harm has been done to Hariot by his admirers than by his opponents; as in the controversy started by Wallis to prove that Descartes borrowed all his algebra from Hariot without acknowledgement, and hence that Hariot

was the greater man. The folly of these disputes is never more regrettable than in their reaction on the individuals who would have been loth to start them. In both cases, of the attempted detraction from Galileo and from Descartes, Hariot has suffered more than by his decent oblivion. But what might have been claimed for him is an interest and a high intelligence in his work, carried on under a tragic illness and under the sense of futility borne in upon him by the deaths of his friends, in those blood and thunder times a little more than three centuries ago.

DRU DRURY, AN EIGHTEENTH CENTURY ENTOMOLOGIST

By Professor T. D. A. COCKERELL
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ALL entomologists are familiar with the name of Dru Drury, one of the fathers of their science in England. Living in the time of Linnæus, when the discovery and description of new forms of life was rapidly increasing the bounds of zoology and botany, he entered fully into the spirit of the new knowledge and contributed largely to it. Something more than an amateur collector, he keenly interested himself in the natural history of insects, and did everything in his power to encourage biological investigations. He corresponded with some of the prominent zoologists of his day, and with many persons in foreign countries, who were interested in collecting insects. His letters were copied, nearly always in his own hand, in a large book. When at Funchal, Madeira, recently, I was greatly interested to find this letter-book in the possession of Mr. C. O. L. Power, of the firm of wine merchants, Power, Drury and Company. Henry Dru Drury, the former head of the business, was my father's greatest friend, and I was named Dru after him. He died in 1888, but Mrs. Power is also a descendant of the entomologist and the letter-book thus still remains in the family. Mr. Power kindly gave me the following pedigree. The known ancestry goes back to Thomas Drury of Fincham in Norfolk, who died in 1545. William Drury, who lived at Godmanchester and Tempsford, had a son Dru Drury, born in 1688. His son, born February 4, 1725, was Dru Drury the entomologist. He is described as of Wood street in the Parish of St. Alban, London, citizen and goldsmith; afterwards of the Strand, of Enfield and of Turnham Green, all in the county of Middlesex, and of Broxbourne, Hereford. He married Easter Pedley, daughter of John Pedley of London, soapmaker. He died January 15, 1804, and was buried at the church of St. Martins in the Fields. He had three children, Mary, born 1749; William (goldsmith, of Turnham Green), born 1752; and Dru, born 1767. William had a son, Henry Dru Drury, born 1799, whose sons were Henry Dru Drury, my father's friend, born 1837, and Charles Dru Drury. The last was the father of Mrs. Power (Gertrude F. Drury), now living at Funchal. Charles Dru Drury, who lived at Blackheath, and died at the early age of 32, was interested in entomology.

I was very kindly permitted to borrow the precious letter book for a number of days, and with my wife's assistance obtained copies of the more interesting letters. These I give in chronological order, but in many cases only portions of letters are quoted. It will be seen that Drury was indefatigable in seeking to enlarge his collection by corresponding with persons living abroad, but that while doing this, he also did his utmost to persuade them to study insects and discover their life-histories. With others, he raised funds to send Smeathman to Africa (letters 18, 19, 25), but he was somewhat embarassed because only insects were received, whereas some of the subscribers asked for and expected other things. He tried to get Thomas James of New York (letter 2) to study the "caterpillars" or nymphs of dragon flies, and in short do the sort of work which Professor Needham has been doing in that state in our own times. In his letters to Dr. Pallas, the eminent naturalist residing in Russia, he discussed the state of affairs in England, and many of his remarks would be pertinent today. We get an account of the circumstances connected with Captain Cook's first expedition, with which Banks and Solander sailed as naturalists. At first it seems a little surprising that there is no mention of Captain Cook, but he was not famous at that time and was not even a captain. We hear of the disappointment occasioned by Banks's failure to publish the expected volumes on the natural history of the voyage. The fact was, that although Sir Joseph Banks was a splendid man and one of the most useful citizens of England, he was not adapted to scientific research, with its continued attention to minute details. His position in relation to natural history was that of a patron and promoter, rather than a student. The correspondence with Moses Harris brings out some of the difficulties in getting the "Illustrations" properly illustrated. Harris, who here appears as the artist, was himself a very capable entomologist who introduced the method of studying the venation of the wings of insects. He published a large work on British Insects, giving names, with descriptions and figures, to a number not previously described. This work has been strangely ignored by subsequent taxonomists, though proper binomials are furnished in the index, as in Drury's Illustrations. Verrall, writing on Diptera, has restored several of the names proposed by Harris. The letter to Linnæus shows the respect Drury had for that great naturalist. In his Illustrations of Exotic Entomology, Drury gave no scientific names in the text, but in the index supplied a full set of binomials, using the strict Linnean method. Haworth, writing in 1807, said that Drury was the first in England to adopt the Linnean method throughout in this manner. Although Drury took so much interest in the correspondents who sent him insects he unaccountably failed to cite them in his book. Their names were, however, found by Westwood in a manuscript list of

Drury's, which also gave more exact localities. When editing a new edition of the Illustrations in 1837, Westwood published much of this information. Drury encouraged Fabricius to study and describe the insects in his collection. There is a good description of the zeal and industry of this great master of entomology, who described a prodigious number of species in a manner which we should now consider inadequate. The Fabrician types in the Banks collection may be seen at the British Museum today. In the preface to the third volume of the Illustrations, Drury complains that whereas he had always thrown his cabinet open to all students, advantage had been taken of this to describe and even figure some of the species without his consent. This was especially unfortunate since it involved a number of forms which were described in the volume and obliged him to suppress the names he had proposed to give them. No name is mentioned, but one has only to look at the index to see that Cramer was the culprit.

At the end, I have quoted a letter describing Drury's business failure, and his fortunate return to solvency or even prosperity. He lived many years longer, but the correspondence of his later years has apparently not been preserved.

Regarding Drury's life and work as a whole, we have an excellent example of that innate taste or passion for natural history which inspires a certain number of individuals in every generation and which the majority can neither appreciate nor understand. But we are also struck by the fact that favorable circumstances are needed to render such aptitudes fruitful and of benefit to mankind. Many such men as Drury, all through the ages, have lived and died without leaving any permanent memorials. The favorable circumstances in Drury's case were especially the organization of zoological and botanical knowledge led by Linnæus, combined with the penetration of nearly every part of the world by British commerce. It was possible to come by the materials for greatly enlarging our knowledge of insects, and a method had been devised for conveniently recording discoveries. Drury, taking advantage of these conditions, was able to make important and permanently valuable contributions to the science he loved so much.

(1) To Mr. Robt. Killingley at Antigua. Jan. 4. 1762.

The Beetles which were in ye spirits among the other things were very acceptable and exceeding pretty, insomuch that I cannot help placing them in ye foremost rank of all the specimens you have now sent, indeed Insects I must confess do really afford me the greatest pleasure of all animals, and as such I will take the liberty of begging a favor of you to try to breed some of the Libellas (vulgarly called horsestingers) [gives full directions for breeding].

(1-a) To Mr. Hough—going to Africa with Capt. Johnson [slaver to to take slaves to Jamaica] March 22, 1762.

The Locusts and Grasshoppers will be found to be very numerous in Africa and also in Jamaica where they differ in a very extraordinary manner from our European ones, some being just like leaf and branch of a tree, others like half a dozen straws joynd together, all of which are very acceptable to us.

(2) To Mr. Thomas James of New York. Apr. 25, 1767.

[Describes apparatus he sends for taking water insects, and continues]:

You may breed a great number of Insects, particularly Libellas, whose cats [nymphs] always live in ye water, for which a few directions will not be unnecessary. Get a large Buckett, pail, or washing tub and put in it some weeds that grow in ye water, fill it three parts full with water and in ye spring; search ye waters above mentioned for Insects and put in it as many Libella Cats as you please. Be sure to put in a great number of ye small sorts, because ye large sorts prey and feed on ye small ones as you will have many opportunities of observing. If you find ye number of small ones decrease very fast you must supply the tub with fresh ones, and once in three weeks or a month change ye water. You must make a contrivance of a frame covered with gauze to go over ye Buckett or Tub so that when ye Libellas are bred they cannot fly away.

(3) To the Rev. Mr. Devereux Jarratt, Virginia. May 13. 1767.

In my letter of July 12th I described ye method of killing Insects by dipping a needle in Aqua Fortis and sticking it into them, but I cannot neglect ye present opportunity of informing you that all that trouble may be saved and the insects may easily be killed by sticking them on ye end of a piece of board and holding them to ye fire, in doing which great care must be taken not to hold them too near, especially Moths or Butterflies, because it will make their wing crumple and contract so much as to spoil them.

(4) To Dr. Pallas. Nov. 12. 1767.

I don't know whether you have heard Mr. Dupont has relinquished collecting of Subjects of Natural History, but so it is, he has given it over and is now very busy making drawings of every specimen he has, and when that is finished intends to dispose of ye whole. Another piece of news I must inform you of is Mr. Da Costa is going to publish plates of nondescript animals—shells, Insects, etc. in periodical numbers, five plates with their descriptions being a complete number. Thus Natural History is I hope gaining ground by slow degrees in this Kingdom. I wish Gentlemen of Fortune studied it more and Politics less. It would I believe be better for us, but at present every man is a politician and sets up his opinion as ye Standard of Judgement, a practice that produces ye greatest distractions among our great men. I

need not mention to you when this is ye case ye Arts and Sciences never flourish so rapidly as when assisted by Concord and Unanimity, but these disadvantages are not sufficient to prevent ye number of Naturalists increasing here and I hope to live to see ye time when ye name will be as respectable as that of a Judge or a Doctor.

(5) To Dr. Pallas. Feb. 28, 1768.

I am delighted with your account of Count Orlof's making natural researches in ye distant parts of ye kingdom. How I honor him for such an attempt! I wish we had a Count Orlof among our Ministers of State: what opportunities he might have in ye present age for discoveries! When all ye known parts of ye Globe are visited by our ships! But oh! these party affairs! These are ye bane of every practicable improvement. Believe me ye little Sphere of Life that I move in makes me neglect no opportunity that may be layd hold of for advancement of natural Knowledge. What then might those Personages do in those grand departments, on whose Nod numbers wait, and where happiness or misery is communicated to thousands by a little motion of a pen. Do you know that we are (the English) possessing ourselves of an island situated near ye Strait Magellan in South America [Falkland Islands], and intend to preserve it as a colony to England? Perhaps you may not have heard of it but so it is. And I have not been idle in endeavoring to get Articles of Natural History from thence. . . .

I have read over your paragraph concerning the India Company very carefully and am afraid your wishes outrun probability, for since I wrote my last I have learned some circumstances that I was then ignorant of. I do not find that they have ever sent out any Botanist or other Naturalist with a settled salary. It is ye curse of this Country for public Bodies seldom to reward ingenuity unless compelled to it by a sense or fear of shame. I could mention many instances of this kind. And their practice has been to send over persons in some inferior office whose circumstances have compelled them to accept it 'tho their merits entitle them to a superior reward. Nor do I know or hear of but one single Gentleman who has a soul generous enough to break through such a mean practice. Indeed if his interest was so great as to become a director (an event not impossible) he would most certainly as I am informed send out some Gentlemen to India with handsome salaries to make inquiries in Natural History. Mr. Sullivan is ye Gentleman I mean. . . .

I sincerely lament with you ye fall of ye Aurelian Society,[1] there wanted but two or three good members to have made it become respectable, but Da Costa's temper and principle was sufficient to overturn a

[1] This seems to have been the first entomological society. There was a later Aurelian Society, before the foundation of the Entomological Society of London.

Kingdom. I imagine ere this you have heard of his *Fate*. If not, I will tell you. He is no longer Librarian to ye Royal Society. He is dismissed from thence with ignominy and disgrace. He was deficient in his accounts above £1100, for which reason they siezed on all his effects, and they are to be sold by public auction. It was no uncommon practice with him to make many Gentlemen annual Fellows in his accounts who had paid their proper quotas to be perpetual ones, and thus by placing them on this footing he annually secreted large sums from ye society. I'll tell you how it was discovered. Dr. Hope of Edinburgh[2] having been chose a Fellow by ye recommendation of a gentleman in London (I believe Dr. Fothergill) was surprised to see his name omitted in ye annual list published, and wrote to London desiring his friend to inquire ye reason; who in examining into ye affair found he was himself entered in ye book as an annual member, tho' at ye same time knew he paid ye necessary sum to become a perpetual one. This neglect in ye librarian being discovered they proceeded to examine several others and found I am told upwards of thirty who were entered in that manner and their fines applied to his own private purpose. Hence ye periodical work he intended to publish, which I mentioned in my last, is entirely stopt; the circumstance I must own I am very sorry for on account of Natural History in general. But if it can not be promoted by men of better principles than him it is better perhaps for it to lye dormant.[3] . . .

I cannot conclude this long Epistle without conjuring you not to let ye summer pass without making captives of all ye insects that fall in ye way. Don't think me too troublesome thus repeating it, for I assure you my desires for knowing what kinds Russia affords are too great to be suppressed. Dr. Solander[4] who I saw yesterday desires his kind respects to you. We are trying to establish a Society upon a more general plan than ye late Aurelian, in which Mr. Fabricius,[5] a very ingenious worthy young Gentleman of Denmark, joins us, and [in] which I hope we shall succeed.

[Count Gregory Orloff, when he failed in his schemes at the Rus-

[2] John Hope, born 1725; was professor of botany and superintendent of the Botanic Garden in Edinburgh. Died 1786.

[3] Da Costa is still remembered by conchologists. For instance, the common *Helix virgata* was named by him.

[4] Daniel Charles Solander was born in Sweden in 1736, and was a pupil of Linnæus at Upsala. In 1760 he went to England, and was chosen to accompany Banks on Cook's first voyage around the world. He died in 1782. He worked in zoology and botany, but is best known as a student and describer of plants.

[5] John Christian Fabricius, born 1742. Died 1807. He was professor of rural and political economy at Copenhagen, but gave most of his time to the study of insects. The "very ingenious worthy young gentleman" was about 26 when the above letter was written.

sian Court, was ordered to travel, and seems to have had ambitious plans. Peter Simon Pallas was born in Berlin in 1741, and went to Russia at the request of the Empress Catharine II, to investigate the natural history of the Russian dominions. He died in Berlin in 1811, having produced works of first class importance, insuring him a permanent place among the great explorers and zoologists of the world. Catharine had a genuine interest in the progress of science and Pallas naturally gave Drury a very enthusiastic account of the work done and planned.]

(6) Dr. Pallas. Apr. 11. 1768.

I cannot help having a great impatience hanging about me to know how Count Orlof's Scheme goes on. I am as anxious for its success as some young Girls are for that of their Lovers: can't you oblige me with some information concerning it. We have a scheme on foot here that is somewhat akin to Count Orlof's, but not on so extensive a Plan. You know ye transit of Venus will happen in June 1769, and as an accurate and nice observation of it in different parts of ye World will be of great utility and consequence to Astronomy, some Gentlemen in that science are to go out this year from hence to ye South Seas in order to make those observations. Mr. Banks, a gentleman of considerable fortune, is extremely desirous of availing himself of this opportunity and going with them in ye same ship in order to make discoveries in Natural History, and to this end is actually making preparations for that purpose.

His being a strong naturalist, possessed of a large fortune, and being determined to spare no expense, are circumstances that give all well wishers to that study ye highest expectations of his success. The route is intended first to ye Madeira Islands, from thence they are to go by easy voyages along ye coast of Brazil, thro ye streights of Magellan, and to refresh at some of ye Spanish towns on ye western coast of South America, having already a passport or permission from ye King of Spain to do so. After they have made ye observation, which is to be done on some Island as much to ye southward as possible, they propose to return to Europe by ye way of ye East Indies. The whole will in all probability not take them less than two years and a half. Hence you perceive we have Gentlemen in Europe whose desires for ye improvement of Nat. Hist are equal to those of any Person in ye World. But I must inform you of one circumstance and that is that Mr. Banks has judgement enough to prevent his engaging in Affairs of State, and consequently by detaching himself from all parties has more leisure to pursue his darling Studies. I wish from my soul we had many more of his Stamp in this kingdom.

(7) Mr. Thomas James, New York. Aug. 1. 1768.

I have sent this (4 guineas) lest you should be in want of ye

money and whatever arises more from ye sail of ye insects I shall certainly remit to you immediately upon my disposing of them. You mention in your last that you are removed forty miles from where you were before. This alteration probably may enable you to discover some new species, a circumstance that will give me great pleasure, particularly if you meet with any new beetles or Insects of ye transparent wing tribe. I shall trust to your ingenuity not to send me any more large *Flies* that you already stock'd me so plentifully with, particularly the large Emperor, the Great Fritillaries, the Black Swallow-Tails and a large Fly of a brown orange color having a black border spotted with white running along ye edges of ye wing both inside and out, ye tendons of wings being black; ye caterpillar is yellow ringed with black having two black horns and two black tails. [This is the milkweed butterfly, *Anosia plexippus*]. You once sent me a black Fritillary of a middling size, a little bigger than your Pearl Border but not near as big as ye great fritillaries, which was much wasted. I wish I could receive a pair or two that were fine

(8) To Mr. Du Pont, going to Jamaica. Oct. 14. 1768.

Please to enquire for Robert Taylor at Mr. Archdeacon's in Spanish Town. He is there as gardener, and well versed in ye knowledge of Insects. I offered him in a letter I wrote to him in August six Pence apiece for ye insects he should send me provided there was not more than two of a sort. Perhaps he may think that price too small and may refuse sending me any on that account, if so I will get you to make ye best bargain ye can with him.

(9) To Dr. Giseke at Hamburg, Nov. 3, 1769. [We read the name Gische, but it is evidently Paul Dietrich Giseke, 1745-1796.]

Mr. Brunnich I find does not abate in his ardour. His resolution in surmounting ye dangers and difficulties of travelling surprises me. I am glad to hear he is in being; when he was in England he promised to write to me often and exchange some insects with me, but I suppose his active state of life prevents him. The Pap. Apollo [*Parnassius apollo*] he was to procure for me some specimens of; if you have an opportunity of sending a letter to him I will entreat you to mention that circumstance. I am sorry to hear of poor Dr. Slosser's death. If he had been of ye same opinion with me concerning inoculation we had not now mourned his loss. I am as ignorant as you of ye place of Mr. Fabricius existence, but I am in daily hopes of hearing from him. I wish I could also give you some account of Mr. Banks and Dr. Solander but I am of opinion we shall learn no news of them till their arrival in England. I can only say may Heaven be propitious to natural history and preserve such capital *Pillars* of it.

(10) To Dr. Pallas. Jan. 14. 1770.

You ask me of what news in Nat. Hist. in these parts. The best I can give you is that it is making great progress here, and the avidity with which books on that subject are bought here is surprising. I mentioned in one of my letters Da Costa's affair. He is now confined in ye King's Bench Prison at ye instance of Royal Society and has been there near a year, from whence, I imagine, he will never return. He is at present engaged in writing a history of shells which he hopes will make its appearance this summer. Pray have you heard of Dr. Schlosser's [6] death? Dr. Giseke, a physician of Hambourge and a great botanist, wrote me word ye 23rd of September, 1769, of this melancholy truth. He died about two months after his wife, who perished with an unborn infant, under ye operation of inoculation. I heartily lament the loss of such a worthy man's death but who can control his fate! I have just rec'd a letter from Mr. Brunnich, who returned from his travels to Copenhagen in October. He tells me he sent you a treatise on Fishes from Leipsic, which he wants to know if you received. He proposes to visit England sometime this year on his way to Scotland.

(11) To Moses Harris at Crayford. Mar. 15, 1770.

I have this day looked out two setts of prints col'd in ye best manner for Col. Gordon and Mrs. Robinson, and in looking them over I observed some plates of fig. 1. plate 12 to be coloured in a manner far from ye original. Those three sets you did last you have made ye spots on each of ye under wings or rather ye patches that are of a beautiful Saxon green in ye fly, in ye plates are mazerine blue, and that part that runs over ye scarlet eyes on ye abdominal edges, you have made of a pea green instead of being ye same color with ye patch itself, which it is in ye natural subject. Likewise in two other sets this figure is coloured blue in one wing and green in ye other which makes it look of such an odd appearance that I dare not venture to send either of them to any person of my acquaintance.

(12) Moses Harris at Crayford. [On Apr. 5, 1770, he writes complaining to M. H. that he is so slow painting the plates and says:]

I wish to Heaven you was removed from that damned place where you are now buried and come to London, for then I could scold you by word of mouth, and now I am forced to employ a great deal of time in doing it by letter which I can but ill spare.

(13) To Dr. Linneus. Aug. 30. 1770.

Most excellent Sr. I cannot better express the strong inclination I have of testifying my respect to you as ye greatest *Master* of natural history now existing than by presenting you a copy of a work I have just published here. Believe me Sr it is not from vanity I take the

[6] Johann Albert Schlosser.

liberty of making you this offering, nor, poor as it is (for I am truly sensible of its defects), would I make it to any person that is inferior to Linneus in the study of Nature. But to whom should I pay my acknowledgements of this sort but to the *Father* of natural history? You Sr I consider as that *Father*, and therefore I beseech your kind acceptance hereof, a circumstance that will do me great honor and favor and at the same time countenance my weak endeavors to promote a study that I must confess to prefer to every other.

Permit me also to take this opportunity to congratulate you on the effects which your *Systema* has had among the followers of natural history here in London, ye number of which, although not equal to those found in many other countries, are yet every day increasing to such a degree as could not have been suspected a little time ago by its most sanguine well wishers. That it may still increase and flourish and that you may, with health, live to see its study carried to ye furtherest ends of ye Earth is ye hearty wish of Sr your sincere admirer and most humble servant.

P. S. The honour of a few lines addressed to me at no. 1, in Love Lane, Aldermanbury, informing me of the Packett having reached the place of its destination, will be exceedingly acceptable.

[In an accompanying list of documents is mentioned a letter, now lost, from Chas. Linnæus, son of the great naturalist. It is probably this letter, dated March 10, 1780, which is printed (pp. x-xi) in Westwood's edition (1837) of Drury's Illustrations of Exotic Entomology. Linæus named a fine Cimex after Drury.]

(14) To Dr. James Greenway. In Dinwiddie Co. Vir. Dec. 18. 1770.

I must not neglect ye present opportunity [to say] that the contents of one of ye vials you sent me was a most acceptable present. It contained some uncommon Insects. I never saw any Juli (for such they were) so large. Permit me to beg you would save for me any of that kind you chance to meet with. I don't mean ye lizards, they are animals I don't collect, but *Insects* are my darling pursuit, therefore any that come under that denomination either large or small will meet a hearty reception. [The Juli are millipedes, not now considered insects, but Drury used the term in the broader sense.]

(15) To Mr. Storm, Principal Gardener to the Hortus Medicus in Amsterdam.

July 19. 1770.

In England we are very fond of other insects besides *Butterflies* and *Moths*, and a small *Beetle* sometimes is more acceptable than a large butterfly.

(16) To Mr. Brunnich, at Copenhagen. Jan. 3. 1772. [Morten

Thrane Brünnich, 1737-1827, a well-known zoologist, especially remembered today in connection with ornithology.]

The little cargo of insects you sent me I received with great pleasure. There were many of them new to me. How happy I should be to have a sight of the *great* collection you certainly must have made in your travels. . . .

In your next letter pray inform me if you have heard anything of Dr. Pallas. I want very much to know whether he is alive, and how he does. I have not had a letter from him since he quitted Petersberg and entered onto that long and dangerous journey into Siberia. I shall also be glad if you will relate this part of my letter to Mr. Fabricius, perhaps he can tell you something concerning him. At the same time you communicate this to Mr. Fabricius I will beg you to present my sincere and best respects to him, and tell him I often think with the highest pleasure of ye many agreeable hours we spent together when he was here in England. How happy I should be to enjoy the same again.

(17) To James Greenway, Dinwiddie Co., Virginia. 1772.

On the 31st of Dec. I received a letter from Dr. Giseke advising me that he had sent a box of books for you, but by a subsequent letter I learned the ship put back by distress of weather after being out about a month. As soon as I receive them I shall convey them to you by the first ship that goes to James River. I suppose it is unnecessary to inform you that the Dr. has been chosen almost unanimously Professor of Natural Philosophy at Hambro', as I have no doubt but his letter will inform you of that matter and likewise ye great satisfaction it has given him, a satisfaction that all his friends cannot help participating. Public testimonies of approbation are seldomer given to men of merit than the undeserving. This is a melancholy truth that is every day seen on this side of the Atlantic and therefore cannot be supposed to come from an invidious pen, therefore what sober thinking mind can help rejoicing at seeing worth rewarded.

(18) To Mr. Thomas Bolton, Worley-Clough, near Halifax.

Feb. 9. 1772.

I take the liberty of recommending my good friend Mr. John Latham,[7] Surgeon at Dartford in Kent, to your friendship and cordiality. He is a gentleman every way deserving it and when I tell you he is a staunch Friend to Natural History I have no doubt but *that* would be sufficient to recommend him to your notice if he had no other amiable qualities, but believe me his general good character is such as will fix him a worthy correspondent. His great Forte is ornithology but other

[7] John Latham; born 1740, died 1837. Eminent as an ornithologist, publishing many important works. He began his General History of Birds, in ten quarto volumes, in his eighty-second year.

parts of Natural History he is acquainted with as *Fossills, Insects* and I think Botany.

I have the pleasure to inform you that I have almost completed the second Volume of Illustrations. A work I think preferable to the first because there are a great many more uncommon insects in it than there was in the former; indeed, it consists entirely of nondescripts, many of which I received from the Coast of Africa, and are such as were never before seen in Europe. I am only sorry I have it not in my power to give the nat. hist. of every one of them, how happy I should be to be able to do that! but so long as distant countries afford few or no men of speculation we must not expect it. A Banks and Solander are to be found only in an Age; and ye wonders of creation must not be expected to be opened and displayed but by slow and gradual means.

Men of Fortune indeed have it in their power to come at this knowledge easier than other people, but when luxury and dissipation fix themselves in any nation, little expectations can be formed in favor of nat. hist. unless it be with those who have wisdom enough to shun those dissolute paths, and secure a mode of entertainment and instruction that will always be found in the tracks of nature. 'Tis with much pleasure we may perceive a few of such persons existing at this time, as a proof of which I need only mention (what I suppose you have before heard) of a gentleman being sent to the coast of Africa to collect the subjects of natural history. His name is Smeathman, and as he is furnished with a general knowledge of nature we form great expectations of having new scenes disclosed to us that were never heard or thot of in that great theatre. He is a man of sense and Letters and therefore qualified to give juster accounts of things than what are at present to be depended on.

(19) Mr. Smeathman at Sierra Leone. Mar. 1. '72.

I desire when you send me the next letter you would be particularly careful to write small, I insist upon it you don't write larger than this. Let me have none of your damned large scrambling characters that won't allow you to put above six words in a line, and by that means prevent me from knowing in what manner you live, how you spend your time and what reception you have met with among the Blacks, how they relish your catching Birds and Flies, whether they laugh at you for so doing and whether you have yet made a journey into the interior parts of the country. In short I want to have ye whole history of ye present life compiled in a sheet of paper, and I am so anxious to hear from you that I most heartily curse this avarice of the Merchts for carrying their ships such an enormous way around as ye West Indies and not sending them directly to Europe. However I sincerely hope you don't neglect recording every circumstance that can enrich a History of Africa, for if you don't publish one when you come home I

think you will deserve to live on "Sordid scraps on surly proud men's doors." Your judgment and abilities strongly enforce ye necessity of it, not only as an emolument to yourself but as a duty you owe to every speculative man, and depend on it much is due from every man of ability in his respective sphere. [In the third volume of the Illustrations Drury quotes many biological observations by Smeathman.]

(20) To Dr. Giseke. July 13, 1772.

I imagine you have heard before this of the situation of Mr. Banks and Dr. Solander with respect to their intended Voyage. They neither of them go any more a kingdom hunting; a misunderstanding between them and our government is the occasion, and Mr. Rheinhold Forster, who published several things, as Centuria Prima Descript. Insectorum, a translation Kalm's Travels in North America etc. is pitched on to go in their room, nay he is actually gone, and tho' his abilities are not considered as equal to those of Banks and Solander yet great expectations are formed by government from him. The event will prove whether they are well founded. I think if I am not mistaken I mentioned in one of my letters my desire of knowing what was become of Dr. Pallas, whether any letters had been received from him lately, and what success had attended his physical voyage? If you can give me any information of these matters I beg you will do it in your next letter. I have not received a line from him these three or four years nor have I been able to get any intelligence about him.

(21) To Mr. Latham, Surgeon in Dartford. July 31. 1772.

Mr. Whiting and Bartlet long to see your Collection of Birds, and if Thursday next will not be inconvenient we will all pack ourselves in a post chaise; but if that day should not be quite agreeable I will beg you to favor me with a line by Monday's post and we will appoint some other time.

(22) To Dr. Kerr at Calcutta. Feb. 12. 1773.

[Writes a long letter begging Dr. Kerr to obtain insects for him, and pointing out the interest of the subject.]

Let me observe further that if your speculations should extend so far as to inquire into the way of life of numberless insects you will have such [word lost] opend as will astonish you and at the same time that you receive the highest entertainment. Mankind may be improved by committing your observations to paper, for we in Europe are ignorant of the Nat. Hist of thousands of animals that live between the Tropics, particularly those of India.

(23) To the Rev. Mr. Devereux Jarrat, May 5, 1773.

I should think myself unpardonable to neglect writing to you by the opportunity that now offers itself. The bearer, Mr. Abbot, is a

young Gentleman going to Virginia on purpose to collect the various articles in Natural History; in doing which he proposes to spend some months, perhaps years, according to the success he meets with in the various departments of that pursuit.

(21) To Mr. Thomas Boulton, at Werley Clough. June 24, 1773.

Mr. Banks and Dr. Solander brought home a very fine collection of insects, a great number of which are new to me and indeed to everybody else. They are not in general so large as one would expect Insects to be that are found in those hot countries they visited; but then many are extremely singular and remarkable. There are *Curculiones* exceeding long and slender like the *Anchraco*, some not less than three or four inches, besides many new species *Scarabei, Chrysomelae* and in short all ye *genera Coleoptrata.* The new species of Lepidoptera are not so numerous as I expected, but these are amply atoned by ye other Orders. I do not as yet know if they intend to publish figures of them among ye other things they intend to give ye world, but I hope they will if ye spirit of kingdom hunting does not possess them too strongly. The plants they brought are very numerous, of which I think Dr. Solander told me they had above seven hundred undescribed. These I know they intend figuring and therefore it is likely you will in time see them all. Mr. Banks is now going to Wales.

. . . .

I think you remember Mr. Fabricius. He is now in London and very busy in making descriptions from Mr. Banks' and my collections, where he will have employment for some months, a pleasure he seems to enjoy with as much glee as a Lover of Wine does ye sight of his Cellar when well stored with full Casks and Bottles, enjoying by anticipation ye pleasure he is to receive in emptying them. You seem to lament the want of a Friend with whom you may converse or correspond on the subject of entomology. Indeed, I am sorry for it and I judge of you by myself whose knowledge and delight therein would soon become trifling and flat if I had no one to talk to on that subject.

I can only say I will with much pleasure answer your letters though perhaps I may sometimes be late in doing it, but believe me I shall be glad to correspond at all times with a friend on these subjects. Your account of ye little Beetles I am much pleased with.

I have read it over a great many times and each time enjoy a pleasure equal to yours when collecting them. How happy are ye men that can thus converse with the great Author of the Universe! For certainly this is holding conversation with him. Can we do it by any other means? Can we consider ye investigation and observation of these his works in any other light than that of preserving and holding a friendly intercourse with him? If it can be explained in any other

manner let those do it whose souls are not sufficiently capacious and susceptible of entertaining and grasping ye vast idea.

(25) To the Dowager Duchess of Portland. Aug. 13. 1773.

May it please your Grace, the subscription to Mr. Smeathman which your Grace inquires after is £100, being the same sum as paid by Dr. Fothergill etc, and which I have no doubt but the things he will send over in less than a twelve month will be more than sufficient to discharge.

(26) To Mr. Keuchan, at Jamaica. June 13, 1774.

You inquire after Mr. Smeathman, who is settled on the Coast of Africa. He has been there almost three years but has sent nothing over except insects, a circumstance which astonishes us, for his patrons expected a great variety of subjects long before this in ye different branches of Natural History. Many of the insects that he has sent are surprisingly fine. A great number entirely new, especially among the Coleoptera, some of which are very large.

(27) To Mr. Keuchan at Jamaica. Jan. 21, 1775.

I told you in my last of a young Gentleman gone to settle in Virginia in pursuit of Nat. Hist. His name is Abbot.[8] and by a letter lately sent I find he intends to remove to the southward, therefore don't be surprised if you should see him at Jamaica; perhaps he may touch there, but I recommended Surinam to him as yielding more wonderful insects etc. Whether he will go there I do not know.

(28) To Dr. Pallas. Nov. 4. 1775.

Mr. Banks's publication nobody can tell when it will make its appearance. Whenever it does it will be not only voluminous but expensive, a circumstance I am surprised he does not attempt to avoid. It has been 4 years preparing, and it seems to me that 4 years more will not complete it. Would it not therefore be best to publish a single volume first? The World thinks so, and he has been told this, but in vain. You require me not to publish any of the Insects you send me. Be assured this requisition shall be punctually observed, and I hope you have given ye same intimation to those Friends to whom you have sent some of your duplicates. Indeed I must inform you that I do not entertain the least inclination to publish any more Volumes, notwithstanding my Cabinet is so exceeding rich. If I was disposed to publish any more I could easily furnish three more volumes equally as

[8] John Abbott, who made many observations on the insects of Georgia, and beautifully figured numerous species. His work was published in part, edited by Sir J. E. Smith, in 1797, and the new species thus made known are credited in our lists to Abbott and Smith. His drawings are now preserved in the British Museum (Natural History).

good as those already done, without having recourse to any other, but my time is so much engrossed by my present business that I have no leisure to go through a work of that kind. If I had time to spare I should pursue it with infinite pleasure. I must give up all thoughts (notwithstanding the solicitations of my friends) of ever again engaging in that employment.

(29) To Mr. Robert Killingley, Mar. 23, 1776.

I shall make no apology for sending you the two books enclosed. Major Roger, Acco' of North America, and Hasselquist's Travels. I wish I could give you equal characters to the two, but ye former seems to me to be taken from Charlevoix Acco' of North America, several passages being copied almost verbatim,—the other I need not praise. you will immediately see ye Man of Letters in ye style and thoughts—the descriptions are charming in my opinion, notwithstanding they are so very short and concise, indeed, I cannot help being angry with him for not being more elaborate and prolix in places.

. . . .

I flatter myself you will enjoy a great joy in ye reading it, your taste for Natural History at all times gives you an opportunity of relishing subjects of this kind with a glee ten times stronger than that of an ordinary person. Need I mention this is ye person that Linneus so often quotes in his Systema Naturæ, and who was so eminently serviceable to him by furnishing so many subjects in that work? [Frederic Hasselquist, born 1722, was a pupil of Linnæus. He made large collections of plants and animals in Palestine and Egypt.]

(30) Dec. 21. 1778.

Last year I lost more than £16,000, the effect of which was, O! terrible to relate, I was obliged to be a Bankrupt. As my misfortunes did not arise from extravagance or dishonesty the world saw my distress and pitied me. By the assistance and kindness of my Friends I have got re-instated in my business, which I really think is much greater than it ever was. The civilities and kindness I have received from the public are beyond conception, and I have no doubt but a few years if Providence allows me Health will place me in a much happier and better situation than I ever was. Would you believe it? The Queen herself, to whom I am Goldsmith, has been so very kind as to say that "She hoped I should do well again."

GALEN: THE MAN AND HIS TIMES

By Professor LYNN THORNDIKE
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FOR about fifteen centuries the name of Galen dominated the study of medicine. But at the close of the nineteenth century an English student of the history of medicine said, "Galen is so inaccessible to English readers that it is difficult to learn about him at first hand." Another wrote, "There is, perhaps, no other instance of a man of equal intellectual rank who has been so persistently misunderstood and even misinterpreted." A third obstacle has been that while critical editions of some single works have recently been published by Helmreich and others, no complete edition even of the Greek text of Galen has appeared since that of Kühn of a century ago, which is now regarded as very faulty. A fourth reason for neglect or misunderstanding of Galen is probably that there is so much by him to be read. Athenaeus stated that Galen wrote more treatises than any other Greek, and although many are now lost, more particularly of his logical and philosophical writings, his collected extant works fill some twenty volumes averaging a thousand pages each. There are often no chapter headings or other brief clues to the contents, which must be ploughed through slowly and thoroughly, since some of the most valuable bits of information come in quite incidentally or by way of unexpected digression. Besides errors in the printed text there are numerous words not found in most classical dictionaries. It is therefore perhaps not surprising, in the words of one of the English historians of medicine quoted above, that "few physicians or even scholars in the present day can claim to have read through this vast collection."

Yet Galen deserves to be remembered, not merely as one of the great names, but as one of most original minds and attractive personalities in all the long history of medicine. It is not difficult to make out the the main events of his life, his works supply an unusual amount of personal information, and throughout them, unless he is merely transcribing past prescriptions, he talks like a living man, detailing incidents of daily life and making upon the reader a vivid and unaffected impression of reality. Daremberg said of Galen that the exuberance of his imagination and his vanity frequently make us smile. It is true that his pharmacology and therapeutics often strike the modern reader as ridiculous, but he did not imagine them; they were the medicine of his age. It is true that he mentions cases which he has cured and those

where other physicians have been at fault, but official war despatches do the same in the case of their own side's victories and the enemy's defeats. *Vae victis!* In Galen's case, at least, posterity long confirmed his own verdict. And dull or obsolete as much of his medicine now is, his scholarly and intellectual ideals and love of hard work are still a living force, while the reader of his pages often feels himself carried back to the Roman world of the second century.

Galen, who does not seem to have been called Claudius until the time of the Italian Renaissance, was born about 129 A. D. at Pergamum in Asia Minor. His father, an architect and mathematician, transmitted much of this education to his son, but even more valuable, in Galen's opinion, were his precepts to follow no one sect or party but to hear and judge them all, to despise honor and glory, and to magnify truth alone. To this teaching Galen attributed his own peaceful and painless passage through life. He did not grieve over losses of property but managed to get along somehow. He did not mind it much when some vituperated him, but thought instead of those who praised him. In later life Galen looked back with great affection upon his father as the gentlest, justest, most honest and humane of men. On the other hand, the chief lesson he learned from his mother was to avoid her failings of a sharp temper and tongue, whereby she made life miserable for their household slaves and scolded his father worse than Xanthippe ever did Socrates.

In one of his works Galen speaks of the passionate love and enthusiasm for truth which have possessed him since boyhood, so that he has not stopped either by day or by night from quest of it. He realized that to become a true scholar required both high natural qualifications and a superior type of education from the very first. After his fourteenth year he heard the lectures of various philosophers, Platonist and Peripatetic, Stoic and Epicurean; but when about seventeen, warned by a dream of his father, he turned to the study of medicine. The incident of the dream, like many other passages in Galen's works, shows that even men of the finest education and intellectual standards were not free from the current beliefs in occult influences. Galen first studied medicine for four years under Satyrus in his native city of Pergamum; then after his father's death, under Pelops at Smyrna, and later under Numisianus at Corinth and Alexandria. This was about the time that the great mathematician and astronomer, Ptolemy, was completing his observations in the neighborhood of Alexandria, but Galen does not mention him, despite his own belief that a first-rate physician should also understand such subjects as geometry and astronomy, music and rhetoric. Galen's interest in philosophy continued, however, and he wrote many logical and philosophical treatises, most of which are lost.

Galen returned to Pergamum to practice and was, when but twenty-nine, given charge of the health of the gladiators by five successive pontiffs. During his thirties came his first residence in Rome. In two of his works he gives two different explanations for his departure from the capital city. In one he says, "When the great plague broke out there (in the reign of Marcus Aurelius) I hurriedly departed from the city for my native land." In another his explanation is that he became disgusted with the malice of the envious physicians of the capital and determined to return home as soon as the sedition there was over. Meanwhile he gained great fame by his cures, but the jealousy and opposition of the other physicians multiplied, so that presently, when he learned that the sedition was over, he went back to Pergamum.

His fame, however, had come to the imperial ears and he was soon summoned to Aquileia, north of the Adriatic, to meet the emperors on their way north against the Germans who had invaded the frontier. An outbreak of the plague there prevented them from proceeding with the campaign immediately and Galen states that the emperors fled for Rome with a few troops, leaving the rest to suffer from the plague and the cold winter. On the way Lucius Verus died, and when Marcus Aurelius finally returned to the front, he allowed Galen to go back to Rome as court physician to his son Commodus. The prevalence of the plague at this time is illustrated by a third encounter which Galen had with it in Asia, when he claims to have saved himself and others by thorough venesection. The war in which Marcus Aurelius was engaged lasted much longer than had been anticipated and meanwhile Galen was occupied chiefly in literary labors. In 192 some of his writings and other treasures were lost in a fire which destroyed the Temple of Peace on the Sacred Way and the great libraries on the Palatine hill. Of some of the works which thus perished he had no other copy himself. He began one of his works on compound medicines of which two books had been already published all over again because most of the published copies had been destroyed in the fire. Galen was still alive and writing during the early years of the dynasty of the Severi and probably did not die until about 200.

Although the envy of other physicians at Rome and their accusing Galen of resort to magic arts and divination in his marvelous prognostications and cures were perhaps neither the sole nor the true reason for his temporary withdrawal from the capital, there probably is a great deal of truth in the picture he paints of the medical profession and learned world of his day. Too many other ancients, from Vitruvius, Pliny the Elder and Juvenal to Firmicus Maternus in the fourth century, substantiate his charges to permit us to explain them away as the product of personal bitterness or pessimism. We feel that these men lived in an intellectual society where faction and villainy, superstition

and petty-mindedness and personal enmity, were more manifest than in the quieter and, let us hope, more tolerant world of our time. The *status belli* may still characterize politics and the business world, but scholars seem able to live in substantial peace. Perhaps it is because there is less prospect of worldly gain for members of the learned professions than in Galen's day. Perhaps it is due to the growth of the impartial scientific spirit, of unwritten codes of courtesy and ethics within the leading learned professions, and of state laws concerning such matters as patents, copyright, professional degrees, pure food and pure drugs. Perhaps, in the unsatisfactory relations between those who should have been the best educated and most enlightened men of that time we may see a symptom of the general intellectual and ethical decline of the ancient world.

Galen states that many tire of the long struggle with crafty and wicked men which they have tried to carry on, relying upon their erudition and honest toil alone, and withdraw disgusted from the madding crowd to save themselves in dignified retirement. He especially marvels at the evil-mindedness of physicians of reputation at Rome. Though they live in the city, they are a band of robbers as truly as the brigands of the mountains. He is inclined to account for the roguery of Roman physicians compared to those in a smaller city by the facts that elsewhere men are not so tempted by the magnitude of possible gain, and that in a smaller town everyone is known by everyone else and so questionable practices cannot escape general notice. The rich men of Rome fall easy prey to unscrupulous practitioners who are ready to flatter them and to play up to their weaknesses. These rich men can see the use of arithmetic and geometry, which enable them to keep their books straight and to build houses for their domestic comfort, or of divination and astrology, from which they seek to learn whose heirs they will be; but they have no appreciation for pure philosophy aside from rhetorical sophistry.

Galen more than once complains that there are no real seekers after truth in his time, but that all are intent upon money, political power, or pleasure. You know very well, he writes to a friend in one of his works, that not five men of all those whom we have met prefer to be rather than to seem wise. Many who have no real knowledge make a great outward display and pretense in medicine and other arts. Galen several times expresses his scorn for those who spend their mornings in going about saluting their friends, and their evenings in drinking bouts or in dining with the rich and powerful. Yet even his friends have reproached him for studying too much and not "going out" more. But while they have wasted their hours thus, he has spent his, first in learning all that the ancients have discovered that is of value, then in testing and practicing the same. Moreover, now-a-days many are try-

ing to teach others what they have never accomplished themselves. Thessalus not only toadies the rich but secured many pupils by offering to teach them medicine in six months. Hence it is that tailors and dyers and smiths are abandoning their arts to become physicians. Thessalus himself, Galen ungenerously taunts, was educated by a father who plucked wool badly in female apartments. Indeed, Galen himself by the violence of his invective and the occasional passionateness of his animosity in his controversies with other individuals or schools of medicine, illustrates that state of war in the intellectual world of his age to which I have adverted.

I suggested that possibly learning compared to other occupations was more remunerative in Galen's day than in ours, but there were poor physicians and medical students then as well as those who were greedy for gain or who associated with the rich. Many doctors could not afford to use the rarer or stronger simples and limited themselves to easily procured, inexpensive, and homely medicaments. Many of his fellow students regarded as a counsel of perfection unattainable by them Galen's plan of hearing all the different medical sects and comparing their merits and testing their validity. These students said tearfully that this course was all very well for him with his acute genius and his wealthy father behind him, but that they lacked the money to pursue an advanced education, perhaps had already lost valuable time under unsatisfactory teachers, or felt that they did not possess the discrimination to select for themselves what was profitable from several conflicting sects or schools.

Galen was, it has already been made apparent, an intellectual aristocrat, and possessed little patience with those stupid men who never learn anything for themselves, though they see a myriad cures worked before their eyes. But that, apart from his own work, the medical profession was not entirely stagnant in his time, he admits when he asserts that many things are known today which had not been discovered before, and when he mentions some curative methods recently invented at Rome.

Galen supplies considerable information concerning the drug trade in Rome itself and throughout the empire. He often complains of adulteration and fraud. The physician must know the medicinal simples and their properties himself and be able to detect adulterated medicines, or the merchants, perfumers, and *herbarii* will deceive him. Galen refuses to reveal the methods employed in adulterating opobalsam, which he had investigated personally, lest the evil practice spread further. At Rome at least there were dealers in unguents who corresponded roughly to our druggists. Galen says that there is not an unguent-dealer in Rome who is unacquainted with herbs from Crete, but he asserts that there are equally good medicinal plants growing in

the very suburbs of Rome of which they are totally ignorant, and he taxes even those who prepare drugs for the emperors with the same oversight. He tells how the herbs come from Crete wrapped in cartons with the name of the herb written on the outside and sometimes the further statement that it is *campestris*. These Roman drug stores seem not to have kept open at night, for Galen speaks of the impossibility of procuring at once the medicines needed in a certain case, because "the lamps were already lighted."

The emperors kept a special store of drugs of their own and had botanists in Sicily, Crete, and Africa who supplied not only them with medicinal herbs, but, according to Galen, the city of Rome as well. However, the emperors appear to have reserved a large supply of the finest and rarest simples for their own use. Galen mentions a large amount of Hymettus honey in the imperial stores—*εν ταις αυτοκρατορικαις αποθηκαις*—whence our word "apothecary." He proves that cinnamon loses its potency with time by his own experience as imperial physician. An assignment of the spice sent to Marcus Aurelius "from Barbary" was superior to what had stood stored in wooden jars from the preceding reigns of Trajan, Hadrian, and Antoninus Pius while after Commodus had exhausted this recent supply and Galen had to turn again to the older store in preparing an antidote for Severus, he found it still weaker than before. That cinnamon was a commodity little known to the populace is indicated by Galen's mentioning his loss in the fire of 192 of a few precious branches which he had stored away in a chest along with other personal treasures. He praises the Severi, however, for permitting others to use theriac, the noted compound medicine and antidote. Thus, he says, they not only as emperors have received power from the gods, but in sharing their goods freely they resemble the gods, who rejoice the more, the more people they save.

Galen himself, and the same seems to have been true of other physicians, was not content to rely for medicines either upon the unguent sellers or the bounty of the imperial stores. He stored away oil and fat, leaving them to age, until he had enough to last him for a hundred years, including some from his father's lifetime. He used some forty years old in one prescription. He also travelled to many parts of the Roman Empire and procured rare drugs in the places where they were produced. Very interesting is his account of going out of his way in journeying back and forth between Rome and Pergamum in order to stop at Lemnos and procure a supply of the famous *terra sigillata*, a reddish clay stamped into pellets with the sacred seal of Diana. On his way to Rome, instead of journeying on foot through Thrace and Macedonia, he took ship from the Troad to Thessalonica; but the vessel stopped in Lemnos at Myrine on the wrong side of the island—Galen had failed to realize that Lemnos had more than one port, and the

captain would not delay the voyage long enough to enable him to cross the island to the spot where *terra sigillata* was to be found. Upon his return from Rome through Macedonia, however, Galen took pains to visit the right port, and for the benefit of future travelers gives careful instructions concerning the route to follow and the distances between stated points.

Galen also describes the solemn procedure by which the priestess from the neighboring city gathered the red earth from the hill where it was found, sacrificing no animals, but wheat and barley to the earth. He brought away with him some twenty thousand of the little discs or seals, which were supposed to cure even lethal poisons and the bite of mad dogs. The inhabitants laughed, however, at the assertion which Galen had read in Dioscorides that the seals were made by mixing the blood of a goat with the earth. Berthelot, the historian of chemistry, believed that this earth was "an oxide of iron more or less hydrated and impure." C. J. S. Thompson, in a recent paper on "Terra Sigillata, a famous medicament of ancient times," tells of various medieval substitutes for the Lemnian earth, and of the interesting religious ceremony performed in the presence of Turkish officials on only one day in the year by Greek monks who had replaced the priestess of Diana. Pierre Belon witnessed this ceremony on August 6th, 1533, by which time there were many varieties of the tablets in existence, "because each lord of Lemnos had a distinct seal." When Tozer visited Lemnos in 1890, the ceremony was still performed annually on the same day, and must be completed before sunrise or the earth would lose its efficacy. Moslem *khodjas* now shared in the religious ceremony, sacrificing a lamb. But in the twentieth century the entire ceremony was abandoned. Through the early modern centuries *terra sigillata* continued to be held in high esteem in western Europe also, and was included in pharmacopeias as late as 1833 and 1848. Thompson gives a chemical analysis of a sixteenth century tablet of the earth and finds no evidence therein of its possessing any medicinal property.

To come back to Galen, in another passage he advises his readers, if they are ever in Pamphylia, to lay in a good supply of the drug *carpesium*. In a third passage he tells of three strata of sory, chalcite, and misy, which he had seen in a mine in Cyprus thirty years before and from which he had brought away a supply, and of the surprising alteration undergone by the misy in the course of those years. He speaks of receiving other drugs from Great Syria, Palestine, Egypt, Cappadocia, Pontus, Macedonia, Gaul, Spain, and Mauretania, from the Celts, and even from India. He names other places in Greece and Asia Minor than Mount Hymettus where good honey may be had. Much so-called Attic honey is really from the Cyclades, although it is brought to Athens and there sold or re-shipped. Similarly genuine

Falernian wine is produced in but a small section of Italy, but imitations are prepared by those skilled in such knavery. As the best iris is that of Illyricum and the best asphalt from Judaea, so the best petroselinos is that of Macedonia, and merchants export it to almost the entire world, just as they do Attic honey and Falernian wine. But the petroselinos crop of Epirus is sent to Thessalonica (Saloniki) and there passed off for Macedonian. The best turpentine is that of Chios, but a good variety may be obtained from Libya or Pontus. The best form of unguent was formerly made only in Laodicea, but now it is similarly compounded in many other cities of Asia Minor.

We are reminded that parts of animals as well as herbs and minerals were important constituents in ancient pharmacy by Galen's invective against the frauds of hunters and dealers in wild beasts as well as of unguent-sellers. They do not hunt the animals at the proper season for securing their medicinal virtues, but when they are no longer in their prime or just after their long period of hibernation, when they are emaciated. Then they fatten them upon improper food, feed them barley cakes to stuff up and dull their teeth, or force them to bite frequently so that virus will run out of their mouths. The beasts of course were also in demand for the games of the arena.

Besides the ancient drug trade, Galen gives us some interesting glimpses of the publishing trade, if we may so term it, of his time. Writing in old age, he says that he has never attached his name to his works and has never written for the popular ear or for fame, but fired by zeal for science and truth, or at the urgent request of friends, or as a useful exercise for himself, or, as now, in order to forget his old age. He regards popular fame as only an impediment to those who desire to live tranquilly and enjoy the fruits of philosophy. He asks Eugenianus not to praise him immoderately before men, as he has been wont to do, and not to inscribe his name in his works. His friends nevertheless prevailed upon Galen to write two treatises listing his works, and he also is free enough in many of his writings in mentioning others which it is essential to read before perusing the present volume. Perhaps he felt differently at different times on the question of fame and anonymity. He also objected to those who read his works, not to learn anything from them, but only in order to calumniate them.

It was in a shop on the Sacra Via that most of the copies of some of Galen's works were stored when they, together with the great libraries upon the Palatine, were consumed in the fire of 192. But in another passage he states that the street of the Sandal-makers is where most of the book-stores of Rome are located. There he saw some men disputing whether a certain treatise was his. It was duly inscribed *Galenus medicus* and one man, because the title was unfamiliar to him, had just purchased it as a new work by Galen. But another man who

was something of a philologer asked to see the introduction, and, after reading a few lines, declared that the book was not one of Galen's works. When Galen was still young, he wrote three commentaries on the throat and lungs for a fellow student who wished to have something to pass off as his own work upon his return home. This friend died, however, and the books got into circulation. Galen also complains that notes of his lectures which he had not intended for publication have got abroad, that his servants have stolen and published some of his manuscripts, and that others have been altered, corrupted, and mutilated by those into whose possession they have come, or have been passed off by them in other lands as their own productions. On the other hand, some of his pupils keep his teachings to themselves and are unwilling to give others the benefit of them, so that if they should die suddenly, his doctrines would be lost. His own ideal has always been to share his knowledge freely with those who sought it, and if possible with all mankind. At least one of his works was taken down from his dictation by short-hand writers, when, after his convincing demonstration by dissection concerning respiration and the voice, Boëthus asked him for commentaries on the subject and sent for stenographers. Although Galen in his travels often purchased and carried home with him large quantities of drugs, when he made his first trip to Rome he left all his library in Asia.

Galen dates the practice of falsifying the title pages and contents of books back to the time when kings Ptolemy of Egypt and Attalus of Pergamum were bidding against each other for volumes for their respective libraries. At that time works were often interpolated in order to make them larger and so bring a better price. Galen speaks more than once of the deplorable ease with which numbers, signs, and other abbreviations are altered in manuscripts. A single stroke of the pen or slight erasure will completely change the meaning of a medical prescription. He thinks that such alterations are sometimes malicious and not mere mistakes. So common were they that Menecrates composed a medical work written out entirely in complete words and entitled *Autocrator Hologrammatos* because it was also dedicated to the emperor. Another writer, Damocrates, from whom Galen often quotes long passages, composed his book of medicaments in metrical form so that there might be no mistake made even in complete words.

Galen's works contain occasional historical information concerning many other matters than books and drugs. Clinton made much use of Galen for the chronology of the period in his *Fasti Romani*. Galen's allusions to several of the emperors with whom he had personal relations are valuable bits of source-material. Trajan was, of course, before his time, but he testifies to the great improvement of the roads in Italy which that emperor had effected, comparing his own systematic

treatment of medicine to the emperor's great work in repairing and improving the roads, straightening them by cut-offs that saved distance, but sometimes abandoning an old road that went straight over hills for an easier route that avoided them, filling in wet and marshy spots with stone or crossing them by causeways, bridging impassable rivers, and altering routes that led through places now deserted and beset by wild beasts so that they would pass through populous towns and more frequented areas. The passage thus bears witness to a shifting of population. Galen also sheds a little light on the vexed question of the number of persons in the empire, if Pergamum is the city he refers to in his estimate of 40,000 citizens or 120,000 inhabitants, including women and slaves but perhaps not children.

The evils of ancient slavery are illustrated by an incident which Galen relates to show the inadvisability of giving way to one's passions, especially anger. Returning east from Rome, Galen fell in with a traveler from Gortyna in Crete. When they reached Corinth, the Cretan sent his baggage and slaves to Athens by boat, but himself with a hired vehicle and two slaves went by land with Galen through Megara, Eleusis, and Thriasa. On the way the Cretan became so angry at the two slaves that he hit them with his sheathed sword so hard that the sheath broke and they were badly wounded. Fearing that they would die, he then made off to escape the consequences of his act, leaving Galen to look after the wounded. But later he rejoined Galen in penitent mood and wished Galen to administer a beating to him for his cruelty. Galen adds that he himself, like his father, had never struck a slave with his own hand and had reproved friends who had broken their slaves' teeth with blows of their fists Other men were accustomed to kick their slaves or gouge their eyes out. The emperor Hadrian was said in a moment of anger to have blinded a slave with a stylus which he had in his hand. He, too, was sorry afterwards and offered the slave money, which the latter refused, telling the emperor that nothing could compensate him for the loss of an eye. In another passage Galen discusses how many slaves and how much clothing one really needs.

Galen also depicts the easy-going, sociable, and pleasure-loving society of his time. Not only physicians but men generally began the day with salutations and calls, then separated, some to the market-place and law courts, others to watch the dancers or charioteers. Others played at dice or pursued love-affairs, or passed the hours at the baths or in eating and drinking or some other bodily pleasure. In the evening they came together again at symposia which bore no resemblance to the intellectual feasts of Socrates and Plato but were mere drinking bouts. Galen, however, had no objection to the moderate use of wine, and mentions the varieties from different parts of the Mediterranean

world which were especially noted for their medicinal properties. He believed that discreet indulgence in wine aided digestion and the blood, and relieved the mind from all worry and melancholy and refreshed it. "For we use it every day." He classed wine with such boons to humanity as medicine, "a sober and decent mode of life," and "the study of literature and liberal disciplines." His three books on food values (*De alimentorum facultatibus*) supply information concerning the ancient table and dietary science.

Galen's allusions to Judaism and Christianity are of considerable interest. He seems scarcely to have distinguished between them. In criticizing Archigenes for using vague and unintelligible language and not giving a sufficient explanation of the point in question, Galen says that it is "as if one had come to a school of Moses and Christ and had heard undemonstrated laws." And in criticizing opposing sects for obstinacy Galen says that it would be easier to win over the followers of Moses and Christ. In a third passage Galen criticized the Mosaic view of the relation of God to nature, resenting it as the opposite extreme to the Epicurean doctrine of a purely mechanistic and materialistic universe. This suggests that Galen had read some of the Old Testament, but he might have learned from other sources of the Dead Sea and of apples of Sodom, of which he speaks in yet another context. According to a thirteenth century Arabian biographer of Galen, he spoke more favorably of Christians in a lost commentary upon Plato's *Republic*, admiring their morals and admitting their miracles. This last is unlikely, since Galen believed in a Supreme Being who worked only through natural law.

Like most thoughtful men of his time, Galen tended to believe in one supreme deity, but he appears to have derived this conception from Greek rather than Hebraic sources. It was to philosophy and the Greek mysteries that he turned for revelation of the deity. Hopeless criminals were for him those whom neither the Muses nor Socrates could reform. It is Plato, not Christ, whom in another treatise he cites as describing the first and greatest God as ungenerated and good. "And we all naturally love Him, being such as He is from eternity."

But while Galen's monotheism cannot be regarded as of Christian or Jewish origin, it is possible that his argument from design and supporting theology by anatomy made him more acceptable both to Mohammedan and Christian readers. At any rate he had Christian readers at Rome at the opening of the third century, when a hostile controversialist complains that some of them even worship Galen. These early Christian enthusiasts for natural science, who also devoted much time to Aristotle and Euclid, were finally excommunicated; but Aristotle, Euclid, and Galen were to return in triumph in medieval learning.

THE MORTALITY OF FOREIGN RACE STOCKS[1]

A Contribution to the Quantitative Study of the Vigor of the Racial Elements in the Population of the United States

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MY interest in this subject arose in connection with another study. Some eight years ago, I began to investigate the reasons for the increasing mortality of the American people after age 45. The mortality figures for the previous decade had shown that, while there had been very marked declines in the mortality rates of our population in infancy, in childhood, and in early adult life, that beginning with the age period 45 and continuing well into old age, there had been a slight increase in mortality. This was very puzzling because such conditions did not appear in England, in Germany, or in the Scandinavian countries for which comparable data were at hand. This was evidently a condition characteristic of America. Why should there be such an adverse change in the death rate during a period of extraordinary activity in public health and when so much was being done to improve the sanitary conditions of the country? Living and working conditions were undoubtedly getting better all the time for the great mass of the population. But these improvements were not being reflected in the facts of the death rate for middle life and beyond. After much labor on this problem, it finally occurred to me that the facts could, perhaps, be explained very simply as the result of the character of our recent immigration. My hypothesis was that, if the foreign stocks that had been coming into the country in increasing numbers actually had a higher death rate than the native stock at the older ages of life, that the very fact of their coming would be sufficient to account for the increase in mortality of the whole population.

To test this hypothesis, it was necessary to construct tables of mortality for the several race stocks, including the native born of native parentage, the native born of foreign or mixed parentage and the foreign born. For the last group, it was necessary also to prepare a table for each one of the important foreign nativity classes. I turned to the data for the State of New York where there was a large representation of the three groups of the population, where registration of deaths was

[1] Read before the second International Congress of Eugenics, Sept. 21, 1921.

good, and where I was fairly familiar with the living and working conditions of the people. Data were for the year 1910. The results were published in the American Economic Review, Vol. VI, No. 3, 1916.[2] Later, assisted by Mr. G. W. Baker, I supplemented the findings for New York State with those for Pennsylvania.[3]

The following is a summary of our chief results. For more details, reference will have to be made to the two papers referred to above.

TABLE 1

Deaths per 1,000 white population among native born of native parentage, among native born of foreign or mixed parentage, and among foreign born, by sex and by age period: New York State, 1910.

Age Period	MALES			FEMALES		
	Native born of native parentage	Native born of foreign or mixed parentage	Foreign born	Native born of native parentage	Native born of foreign or mixed parentage	Foreign born
Ages 10 and over:						
Crude rate	13.8	13.2	17.5	12.4	9.7	16.6
Standardized rate	13.8	17.2	17.1	12.4	13.9	16.2
10-14	2.5	2.2	2.5	2.6	2.1	2.4
15-19	3.6	4.1	4.4	3.2	3.2	3.2
20-24	5.0	6.8	5.2	4.7	5.2	4.0
25-44	6.9	14.3	8.7	5.7	9.3	7.3
45-64	18.8	28.2	28.0	14.3	20.0	23.4
65-84	77.3	89.9	90.4	68.2	73.9	87.7
85 and over	268.9	323.0	272.7	242.3	324.9	270.5

Table 1 presents a comparison of the actual facts of mortality in three principal classes according to nativity in the population of New York State in 1910. In both sexes, the death rates of the foreign born and of their native born offspring are considerably in excess of those for the native born of native parents after the period of middle life is reached. There is little difference during the periods of childhood, of adolescence, and of early life; but there the similarity ceases. The excess mortality of the foreign stock reaches its maximum at about age 60 and continues to the end of life but to a less degree. In the important age period 45 to 64, the death rate of males (28.0) was 49 per cent. higher than that for native males of native parentage and that for foreign born females was 64 per cent. higher than for females of native stock. Similar conditions exist in the State of Pennsylvania.

In view of the fact that the foreign born and their native offspring make up a considerable proportion of the total population of both New York (63.9 per cent.) and Pennsylvania (43.5 per cent.), there is no room for doubt that our explanation of the increasing mortality

[2] Factors in American Mortality. A Study of Death Rates in the Race Stocks of New York State, 1910.

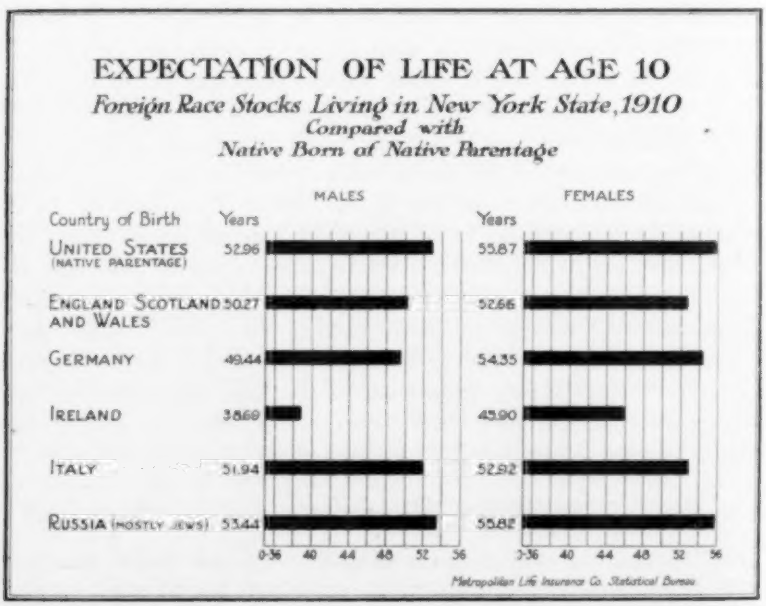
[3] The Mortality of Race Stocks in Pennsylvania and New York. Quarterly Publications American Statistical Association, March, 1920.

after age 45 is correct. The foreign born enter the United States, for the most part, as adults; they have lower vitality than the native stock and their addition to the population can have only one effect, namely, to increase the death rate at the middle ages of life and at the older ages.

Our problem today, however, is somewhat different. I propose to give you the results of our investigations with especial reference to the relative vigor of the several race groups that make up our newer immigration. Obviously, that is what will interest you as eugenists concerned as you are with the character and potentialities of the various groups which are making the American of the future.

To determine the relative vitality of the several race stocks, we constructed a series of life tables from the facts of mortality already referred to. There is no better test; for they tell us the average after lifetime of each group. The figures of expectation were calculated beginning at age 10 in each case because of the small number of foreign born persons living in New York State below this age. The figures for the five principal foreign races are given in the following charts, the countries of foreign birth being arranged alphabetically. The expectations for those born in the United States of native parentage are given for comparison.

With the exception of the Russian born, the native males of native parentage have a greater expectation at age 10 than any of the foreign groups. In New York State, the Russians are almost entirely Jews who are noted for their longevity. At age 10, the expectation



of Russian born males is 53.44 years, as compared with 52.96 years for native males of native parentage. Similar conditions have been described by various observers for Jews living in Germany, Russia and Hungary. They invariably have lower death rates and longer expectation of life than do the people among whom they live. Their addition to the population of New York State has, therefore, an effect very different from that of the other foreign peoples. They increase the longevity of the total population rather than decrease it. Next in order of longevity are the Italian males with a life span of nearly 52 years at age 10; next are the English, Scotch and Welsh, 50.27 years; the Germans, 49.44 years; and the Irish, 38.69 years. The surprising fact of this chart is the very low life expectation of the Irish males. It is actually two years less than the expectation of negro males living in the Registration States at the same age. We shall attempt later to give some of the causes which are responsible for very unfavorable conditions in this race.

Among foreign born females, very similar conditions appear. The greatest expectation is found among Russian born females, who, at age 10, have an average after lifetime of 55.82 years. This is almost identical with the expectation of females of native stock. Then follow in the order named the females born in Germany, Italy, England,

TABLE 2

Expectation of life at selected ages. By sex, for persons born in specified country and living in New York State, 1910:

Sex; country of birth	10	20	40	60
Males: Living in New York State, 1910, Born in:				
United States (native parentage)	52.96	44.80	29.22	14.92
England, Scotland and Wales	50.27	42.23	26.79	13.78
Germany	49.44	40.80	25.51	13.25
Ireland	38.60	31.35	18.16	11.25
Italy	51.94	44.26	28.75	15.08
Russia (mostly Jews)	53.44	44.84	27.85	13.95
Living in specified country:				
England and Wales, 1910-1912	53.08	44.21	27.74	13.78
Scotland, 1911	51.86	43.27	27.25	13.54
Germany, 1901-1910	51.16	42.56	26.64	13.14
Italy, 1901-1910	51.25	43.00	28.00	13.67
Females: Living in New York State, 1910, Born in:				
United States (native parentage)	55.87	47.55	31.57	16.30
England, Scotland and Wales	52.66	44.01	28.17	14.86
Germany	54.35	45.57	29.31	14.60
Ireland	45.90	37.40	22.20	11.30
Italy	52.92	44.94	29.68	15.66
Russia (mostly Jews)	55.82	46.60	29.84	14.73
Living in specified country:				
England and Wales, 1910-1912	55.91	47.10	30.30	15.48
Scotland, 1911	53.83	45.35	29.48	15.17
Germany, 1901-1910	53.35	44.84	29.16	14.17
Italy, 1901-1910	51.50	43.67	29.00	13.92

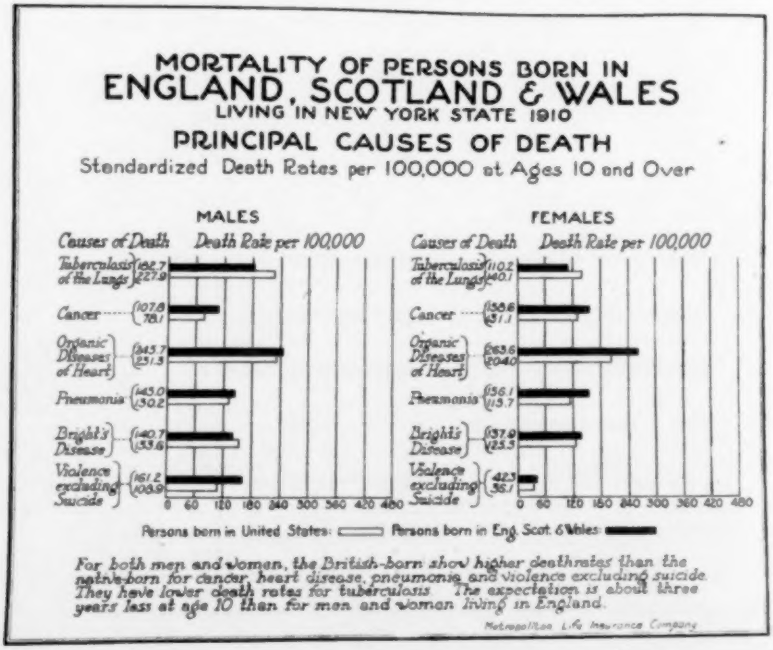
Scotland and Wales, and Ireland. In every case, the expectation of life for females is in excess of that for males of the same nativity group. The excess varies from seven years among the Irish to only about one year among the Italians.

The following table shows similarly the facts of the expectation at other age periods than 10 for each one of the foreign race stocks as compared with the native born of native parentage:

In view of the interest that attaches to the several race stocks, we present a chart for each of them which shows the facts of mortality for the principal causes of death.

English, Scotch and Welsh

The mortality rates of the British are among the most favorable in Europe. Their addition to the population of New York State might, therefore, be expected to be a favorable one. Yet, as we have seen, the expectation of life of both males and females of this nativity falls from two to three years short of that of the native stock at age 10. The fact is that the expectation of the British living in New York State is about three years less than for men and women living in England. Among the several causes of death, we find higher death rates among the British born for cancer, organic heart disease, pneumonia and violence. They have lower death rates for tuberculosis. The differences are never very great and it is difficult to single out any particular cause of death as especially responsible for the conditions described. For our purposes, however, it is important to remember that the



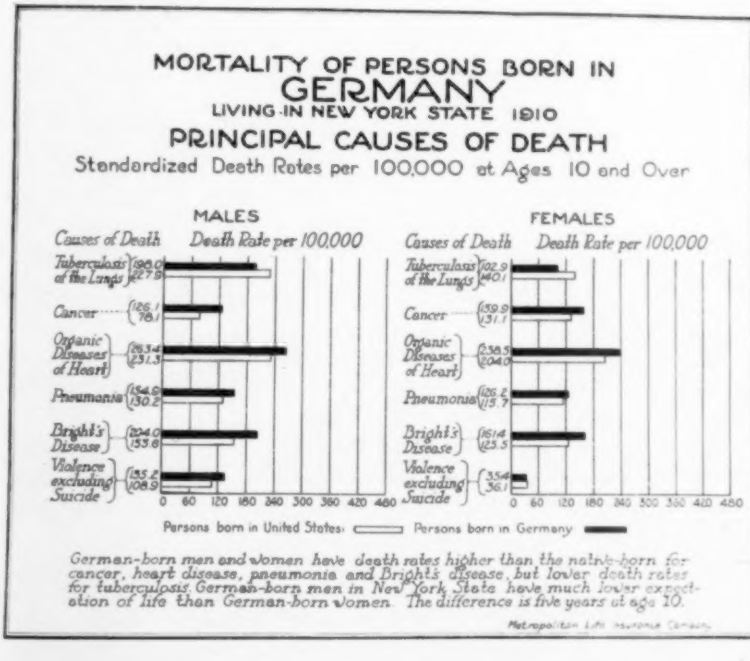
British immigrant living in New York State does not show up as favorably either as do his own people in his native country or as the native stock in the United States.

Immigration from England, Scotland and Wales into the State of New York has been of minor importance in recent years. In 1910, there were only 193,359 of these foreign born people in New York State, constituting 7.1 per cent. of the foreign born and only 2.2 per cent. of the total white population of the state.

Germans

The Germans constitute a very much larger group of the foreign stock in this state. In 1910, there were 436,874 German born persons, constituting 16.0 per cent. of the foreign born whites and 4.9 per cent. of the total white population.

In this group, the males show up much worse than do the females. The longevity of males, as measured by the life tables at age 10, is fully three and one-half years less than that of native males of native parentage; while the German born females have an expectation only one and one-half years less than that of females of native stock. With the exception of tuberculosis, German born men and women have higher death rates than the native born for all important causes of death. The so-called degenerative diseases play a very important part in their high mortality. Heart disease and Bright's disease both show excessive rates among males and females. Cancer is also much



higher among them than in the native population. Suicide is also an important element, although not shown in the chart. The mortality characteristics of the German born living in New York State recall similar facts for the native population of Germany, but to an exaggerated degree. The mortality rates of Germans living in their native country have shown remarkable improvement during the decades prior to the war and were among the most favorable in Europe. German males living in New York State showed an expectation of life almost two years less at age 10 and considerably higher death rates for the principal causes than are found for the Germans in their own country.

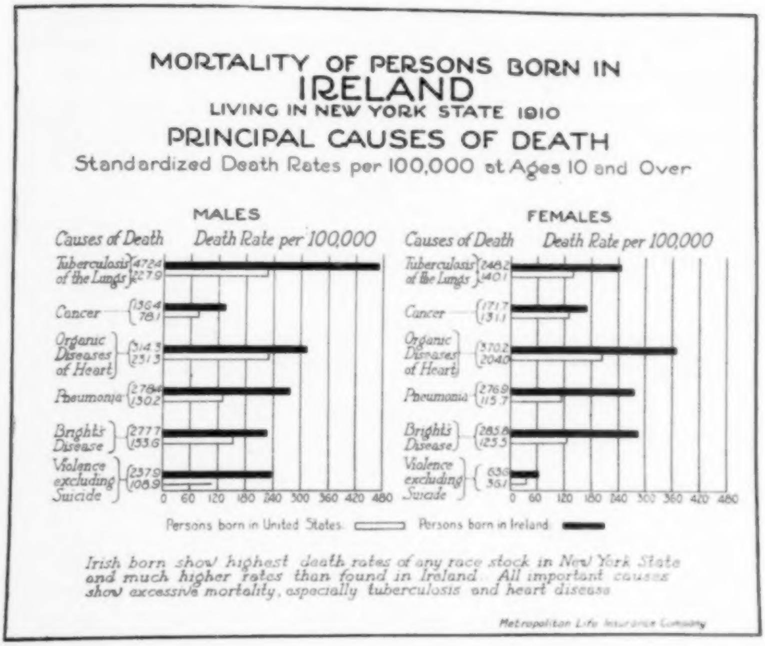
Irish

The Irish living in New York State present a very serious situation from the standpoint of longevity. They form an important part of the population, representing in 1910, 13.5 of the total foreign born and 4.1 per cent. of the total white population of the state. The high point in the immigration of this race was reached long ago, so that today we must consider not only those who were born abroad but their native born children as well. The Irish stock in New York State in 1910, thus considered, comprised 12.2 per cent. of the total white population in 1910.

A very high death rate is coupled with the numerical importance of this race. The effect on the mortality condition of the entire population is, therefore, considerable. As shown in Chart 1, the longevity as measured by the expectation of both Irish born males and females is least of any of the foreign stocks listed. Striking excesses of mortality exist. Thus, Irish males at the age period 25 to 44 have a death rate of 18.5 per thousand, or nearly three times that for native males of native parentage (6.9 per thousand). Irish born females at the same age period show a rate of 12.0 per thousand, much less than for Irish males, but nearly twice that of native females of native parentage. Taking all ages 10 and over together and with due regard to the differences of age distribution, we find that the standardized death rates for both Irish males and females are about twice that for natives of native parentage.

The following chart shows that these results follow from an excessive mortality from every principal cause of death, but especially so from tuberculosis, pneumonia, and violence:

It is difficult to understand these facts in view of the rather favorable mortality condition of the Irish in their own country. The figures for those living in New York State are not far from twice as high as those reported by the Registrar General of Ireland for the more important age periods of life. The factors which produce these differences will repay further study.



Italians

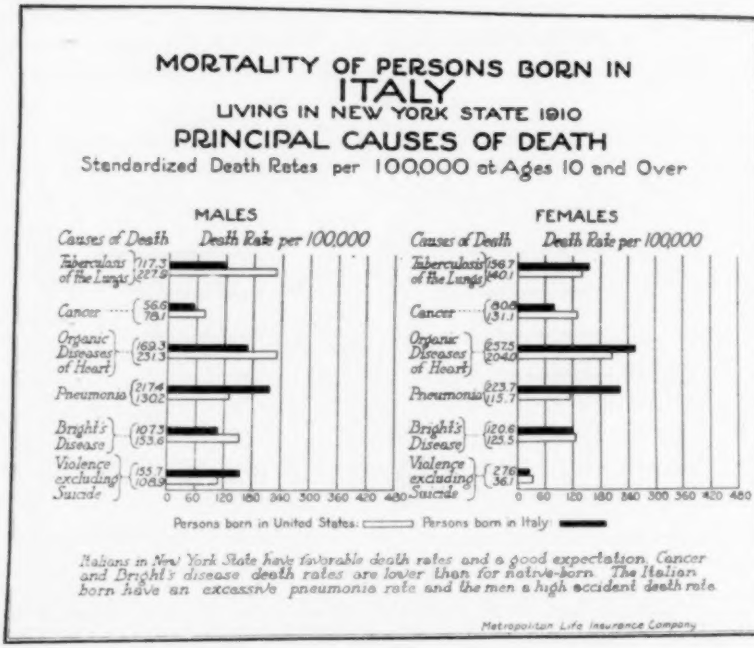
The Italians have very favorable death rates in New York State and enjoy a good expectation. In this respect, the Italian born males show up relatively better than do the females. Among the males, we observe especially low rates for tuberculosis, cancer, heart disease and Bright's disease. On the other hand, they have higher death rates from pneumonia and violence, both of which may well reflect the hazards peculiar to their occupations.

Italian born females, unlike the males, have relatively high death rates from tuberculosis of the lungs and organic heart disease. Like the males, they have high pneumonia rates. The figures indicate that the conditions of life in New York State are not particularly favorable for Italian women in spite of a good endowment of bodily vigor.

It is important to note that in spite of the marked change in the environmental conditions in New York State as compared with their native country, which, for the large majority of the Italian immigrants is the warm south, the Italian born live longer and suffer less from most serious diseases in their new abode than in their home country.

According to the 1910 census, the number of persons of Italian birth in New York State was 472,192. This was 17.3 per cent. of the foreign born whites and 5.3 per cent. of the total white population. This number is large in view of the recent date at which the Italian immigration began. A steady stream of this nativity may be

expected to come to the United States. Their addition to the population from the point of view of longevity involves little, if any, loss to the total population.

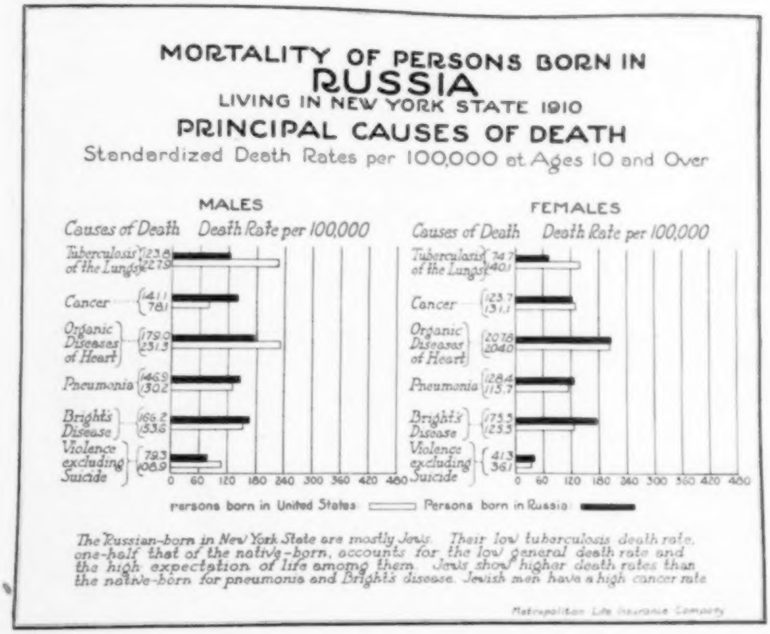


Russians

The Russian born living in New York State form the largest group among the foreign stocks studied. In 1910, there were 558,952, or 20.5 per cent. of the total foreign born and 6.2 per cent. of the total white population. Although no absolutely trustworthy figures are available, it is obvious that in New York State, the Russian born are, for the most part, Jews, and it is this fact that explains the very low death rate and greater longevity which the Russian born enjoy. As shown in Chart 1, both males and females of this race have an expectation as good as the native born of native parentage; in fact, the males are slightly better than the native stock. The full significance of this fact appears when we consider the very favorable conditions of life of this people in their new environment. They are, for the most part, relatively newcomers and, many of them are still suffering from the difficulties arising out of poor housing and of bad economic status incidental to a period of adjustment in a new country. This fact again bears out what is generally known—that the Jews as a people have extraordinary vigor.

As shown in Chart 6, these Russian born in New York State have very much lower death rates from pulmonary tuberculosis than is found among the native born. In the age period 25 to 44, for example,

males show a tuberculosis death rate of 117.1 per 100,000, as compared with 352 among natives. Females, likewise, at this same age period, show a tuberculosis death rate a little more than one-half that of native born females. It is this favorable condition as to tuberculosis which almost by itself explains the favorable mortality which is observed in this race. On the other hand, Bright's disease is higher among these people, especially in the later age periods. Likewise cancer has an excessive death rate among males. The low death rate from violent causes points to the absence of hazard in the occupations engaged in by them.



Summary and Conclusion

We may, therefore, conclude that:

1. The several races that make up the foreign born population of New York are variable as to their natural vigor as measured by their mortality rates or by life tables.

2. With the exception of the Russians, who are, for the most part, Jews, the expectation of life of the foreign born is less than for the native born of native parentage.

3. Of the foreign born, Russians have the best expectation followed in order by the Italians, the English, Scotch and Welsh, the Germans, and the Irish. The last have a particularly low expectation.

4. With the exception of the Russians and Italians, the mortality

is higher among these races living in New York State than in their native country.

5. This condition may be due to the difficulties of adjustment to new conditions of life; or to the poorer quality of the immigrants as compared with their own people who stay at home, or to a combination of both these factors.

THE PROGRESS OF SCIENCE [1]

THE TORONTO MEETING OF THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

As guests of the University of Toronto and the Royal Canadian Institute, the American Association for the Advancement of Science holds its seventy-fourth meeting at the University of Toronto from December 27 to 31. Meeting with the various sections of the association and in many cases joining in their programs are twenty-five associated societies.

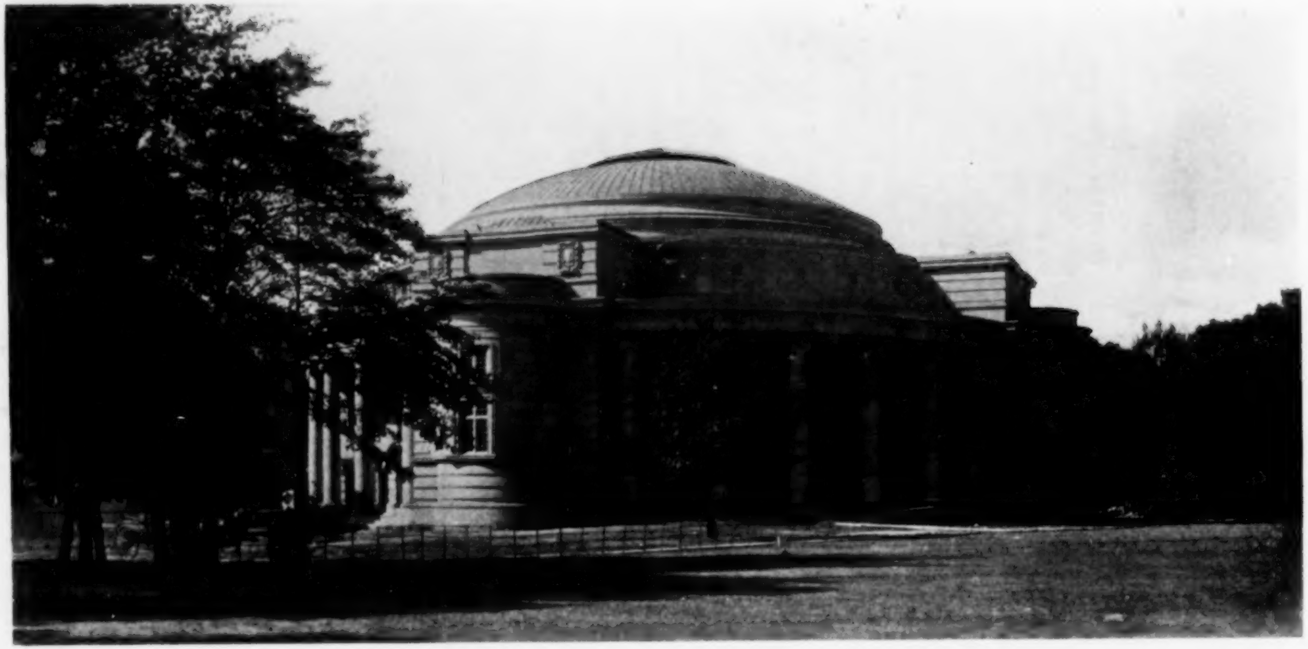
The association is American, its field covering North, Central and South America, but it has never met south of the United States. Its last meeting in Canada was at Toronto twenty-two years ago. Previous meetings had been held in Montreal in 1857 and 1882.

Professor Eliakim Hastings Moore, head of the department of mathematics at the University of Chicago, will preside at the general sessions. Dr. L. O. Howard, chief of the Bureau of Entomology of the U. S. Department of Agriculture, will deliver the address of the retiring president on the evening of the first day, his title being, (a) "On some presidential addresses; (b) "The War on the Insects."

At the joint invitation of the American Association and the American Society of Zoologists, Dr. William Bateson, director of the John Innes Horticultural Institution, England, will attend the meetings and

[1] Edited by Watson Davis, Science Service.

MAIN BUILDING, UNIVERSITY OF TORONTO



CONVOCATION HALL, UNIVERSITY OF TORONTO

HART HOUSE

will make his principal address before a general session on "The Evolutionary Faith and Modern Doubt."

Another address before a general session of the American Association will be delivered by Sir Adam Beck, chairman of the Hydro-electric Commission of Ontario, his subject being "Hydro-electric Developments in Ontario," illustrated by motion pictures. Sir Adam Beck's address will be under the auspices of Section M (Engineering) which has on its program other papers on engineering progress in Canada, including oil developments in the far north, mining operations in eastern Canada and problems of railway engineering.

Among the symposia, most of them arranged jointly by a section of the American Association and related societies, are: Insects as disseminators of plant diseases, origin of variations, utility of the species concept, orthogenesis, The quantum theory, Frost resistance and winter killing of plants, Synoptic weather charts, Cooperation of Canada and the United States in the field of agriculture, Crop zones, The structure of the atom, The child: Its health and development.

In addition to the scientific and technical programs, entertainments and social features have been arranged by the local committee, including a reception at the Royal Ontario Museum, which contains some of the finest scientific collections on the continent, an informal conversazione in Hart House, also boxing, wrestling, fencing, basket-ball, gymnastics, group games, diving, swimming, band music and bag-pipe music, water polo and indoor baseball in Hart House, an exhibition of artistic skating and an ice hockey match, and a showing of popular educational motion pictures on various subjects. An exhibition of new apparatus for scientific research and new scientific products will be held in the university's exhibition hall.

The facilities and entertainment offered the American Association by the University of Toronto and the Royal Canadian Institute promise to be a great factor in the success of the meeting. The University of Toronto compares favorably in size

and equipment with the leading American universities. Hart House, the social and recreational center of the university, contains assembly halls, libraries, a complete gymnasium, dining halls and a well-equipped theater.

The Royal Canadian Institute, Canada's oldest scientific society, is made up of professional, scientific and business men interested in scientific progress. Jointly with the University of Toronto, this organization has made the arrangements for the meeting.

Several Canadian scientific societies will join with the American Association in its meeting, among them being the Royal Astronomical Society of Canada. The societies associated with the American Association which will join in the Toronto meeting are: The American Mathematical Society, The Mathematical Association of America, The American Physical Society, The American Meteorological Society, The American Society of Zoologists, The Entomological Society of America, The American Association of Economic Entomologists, The Botanical Society of America, The American Phytopathological Society, The American Society of Naturalists, The Ecological Society of America, The American Microscopical Society, The American Nature-Study Society, The American Metric Association, The Society of American Foresters, The American Society for Horticultural Science, The Association of Official Seed Analysts, The Society of Sigma Xi, The Gamma Alpha Graduate Scientific Fraternity, and the Phi Kappa Phi Fraternity.

THE AMERICAN ORNITHOLOGISTS' UNION

Ornithologists of the country gathered at Philadelphia from November 8 to 11 to attend the thirty-ninth annual meeting of the American Ornithologists' Union. Forty papers and eighteen reels of motion pictures were presented during the meeting and bird naturalists from as far away as Holland, England and the Pacific coast were in attendance.

A large number of papers were about South American and tropical birds, ranging in habitat from Panama to Patagonia. Bird banding in its various phases was considered in other papers and there was the usual quota of technical papers on bird names, life habits and history.

The union recorded a net gain of 264 members added to a membership which already at the beginning of the meeting numbered 1,350.

Four American Ornithologists were given the highest honor that can be conferred upon them by their fellow workers when they were elected to fellowship in the union. The number of fellows is limited to fifty, and with these four elections only one vacancy remains. Those honored were: Dr. W. H. Bergtold, an ornithologist and practicing physician of Denver, Colorado; Major Allan Brooks, of Okanagan, British Columbia; James P. Chapin, American Museum of Natural History, New York City, and Dr. Glover M. Allen, Boston Society of Natural History.

Five members, the grade of membership next lower than fellow, were elected as follows: S. Prentiss Baldwin, expert on banding birds, Cleveland, Ohio; George L. Fordyce, treasurer of the Wilson Ornithological Club, Youngstown, Ohio; F. C. Lincoln, Biological Survey, Washington, D. C.; C. H. Rogers, Princeton University, and Dr. Casey A. Wood, Chicago.

The entire quota of twenty-five honorary fellows from foreign lands was filled for the first time since 1890 by the election of five foreign ornithologists. Fourteen corresponding fellows, all foreign, were also elected.

Memorial addresses on three fellows who died during the past year

were delivered. The deceased fellows are: Dr. J. A. Allen, American Museum of Natural History, New York City; Charles B. Cory, Field Museum, Chicago, Illinois, and William Palmer, U. S. National Museum, Washington, D. C.

The Brewster Memorial Medal was awarded to Robert Ridgway, of the U. S. National Museum, for his work on the "Birds of North and Middle America," vol. 8, which in the judgment of the council was the most meritorious work on American birds published during the last two years. This medal is to be awarded biennially, and this is the first award.

A feature of the annual banquet was the appearance in costume of representatives of Alexander Wilson, John James Audubon, and C. S. Rainesque, pioneer bird lovers who lived in Philadelphia in the early half of the nineteenth century.

The following were elected officers: Dr. Witmer Stone, Academy of Natural Sciences, Philadelphia, *president;* Dr. George Bird Grinnell, New York City, and Dr. Jonathan Dwight, New York City, *vice presidents;* Dr. T. S. Palmer, Biological Survey, Washington, D. C., *secretary;* and W. L. McAtee, Biological Survey, *treasurer.*

SUSPENSION OF GOVERNMENT SCIENTIFIC PERIODICALS

Important scientific periodicals of the Department of Agriculture have suspended publication owing to the failure of the Congress to give specific authority for their continuance after December 1, the date set by law for the death of all government periodicals not individually authorized by the Congress.

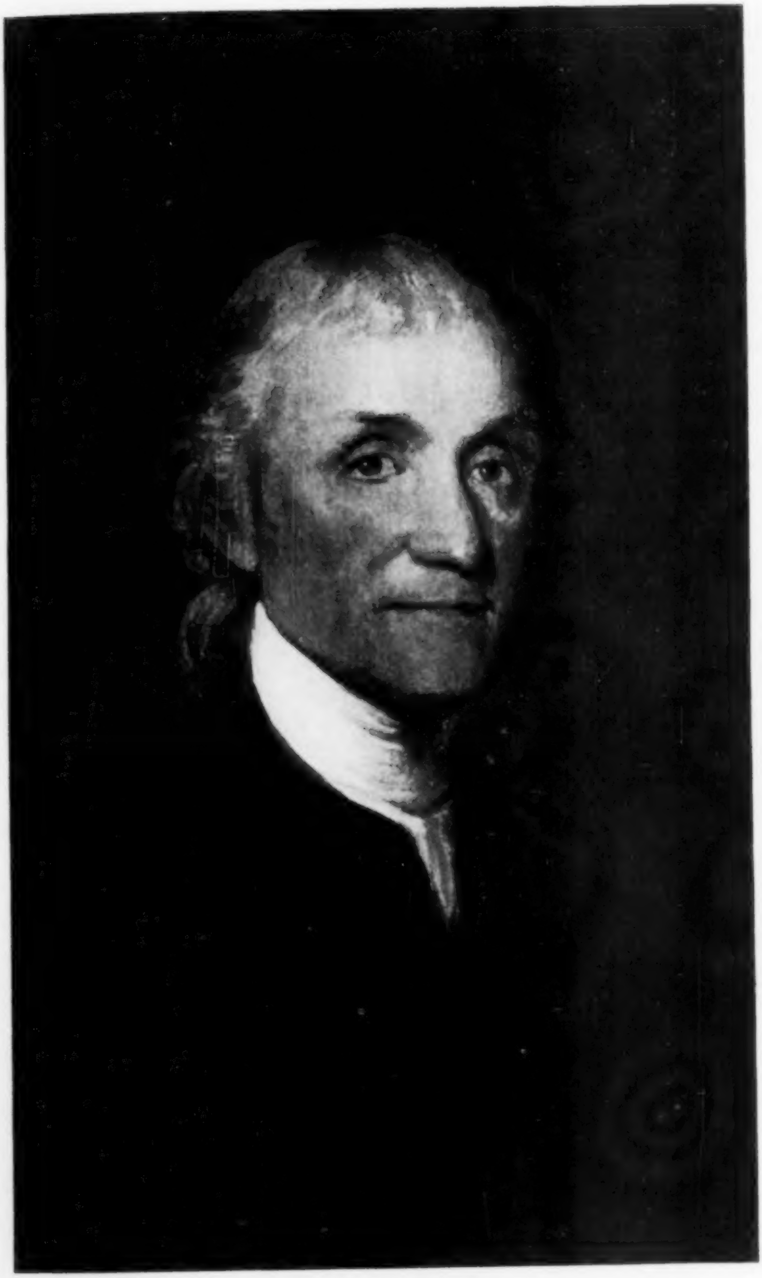
When the Congress adjourned without giving any committee authority to determine which periodicals should continue to appear, some forty-one publications issued by the government departments suspended publication, in most cases without any notice.

From a scientific standpoint, of those that are suspended, four Department of Agriculture publications are the most important. *The Experiment Station Record,* with its concisely written abstracts of agricultural literature, knitted together the research activities of the universities and agricultural experiment stations. *The Journal of Agricultural Research* was the medium for making public those researches that as yet would hardly be of general interest to the practical farmer. But in this journal have been announced some of the most important experimental work of the department and affiliated experiment stations. Meteorology in all its phases was the field of the *Monthly Weather Review,* edited from the Weather Bureau. *Public Roads* had a circulation of 4,000 copies a month and carried details and research of the federal aid program to engineers and road builders.

Four other Department of Agriculture periodicals were doing a real service. *The Weekly News Letter,* circulation 126,000, kept the 106,000 collaborators and employees of the department in touch with its activities and served to take current information to those especially interested in agriculture. Weather data were carried promptly to 3,300 by the weekly *National Weather and Crop Bulletin.* The weekly *Market Reporter* was published to give 11,200 bankers, colleges, economists and others prompt data on live stock, grain, produce and other agricultural prices. The *Monthly Crop Reporter,* with an edition of 114,500, was sent to libraries and organizations interested in agricultural estimates, but the bulk of the edition went to collaborators of the department who aid in compiling crop statistics.

By suspending the forty-one government periodicals, it has been estimated that from $500,000 to

JOSEPH LEIDY
Statue erected in the Medical School of the University of Pennsylvania in honor of the distinguished naturalist and anatomist



JOSEPH PRIESTLEY
Photograph from the copy of the portrait by Gilbert Stuart, recently presented to the United States National Museum by the American Chemical Society

$1,000,000 will be saved each year, but this may be mistaken economy. It is not inconceivable that even the temporary suspension of the periodicals mentioned may cause a much greater loss to the country than the saving on the forty-one periodicals.

The inability to publish the results of important government researches is becoming a serious situation, even apart from the suspension of the scientific periodicals. Printing appropriations of practically all government scientific bureaus have been greatly reduced, and only the manuscripts that are most important can be published, and these often after undue delay.

SCIENTIFIC ITEMS

We record with regret the death of Bert Holmes Hite, professor of agricultural chemistry in the University of West Virginia; of William Speirs Bruce, oceanographer and polar explorer; of Etienne Boutroux, professor of philosophy at the Sorbonne; of Dimitri Konstantinovitch Tschernoff of Petrograd, known for his work on the metallography of iron; of Ch. François-Franck, formerly lecturer on physiology at the Collège de France; and of Julius Hann, Austrian meteorologist.

Elimination of industrial waste was the principal topic discussed at the forty-second annual meeting of the American Society of Mechanical Engineers held in New York City from December 5 to 9. Separate sessions were held to consider the wastes of power generation, machine shops, railways, use of fuel, materials handling, textile manufacture, wood manufacture, and the aeronautic industry. A national program of industrial education and training as a fundamental necessity in the development of the industries of this country also had a place on the program. Honorary membership was awarded to Henry R. Towne, directing head of the Yale and Towne Manufacturing Co., and Nathaniel G. Herreshoff, who has played a large part in the development of the science of naval architecture both through his interest in yacht racing and his work on commercial and war vessels.

The relation of chemical engineering to national defense was the leading topic of the fourteenth annual meeting of the American Institute of Chemical Engineers held in Baltimore, December 6 to 9. Visits were made to Edgewood Arsenal and to various Baltimore industries.